SERVICE INFORMATION
PHYACTION 740 & 790 SERIES

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CHAPTER 1 GENERAL INFORMATION

1.1 Introduction

The Phyaction 796 is an appliance for ultrasound therapy, electrotherapy (1 channel medium frequency or TENS), combination therapy (MF & US) and laser therapy. The Phyaction 792 is the same as the 796, except that it can't support laser therapy. The Phyaction 793 is the same as the Phyaction 792, except it also contains rectified currents for electrotherapy. The Phyaction 740 can only be used for laser therapy. In this manual the Phyaction 796 is described because it is the most extensive model in the series and the Phyaction 793 for the rectified currents.

In this chapter the important features from the users manual for service personnel are listed. In the next chapter the theory of operation will be explained. In chapter 3 is described how service personnel can check the operation of a 796 and in chapter 4 the adjustments which can be executed by service personnel are explained. The next chapter contains information which could be very useful for trouble shooting such as the description of the automatic self test and a list of the error numbers. The schematic diagrams are in chapter 6, the spare parts list in chapter 7 and a list of all the modifications is in the last chapter.

1.2 Safety aspects

1.2.1 Electrical safety

The equipment can only be used in areas with provisions in accordance with current statutory requirements. Pay particular attention to the use of protective earth, otherwise the patient leakage current can rise above the permitted limit for type B equipment.

1.2.2 Explosion safety

The equipment is not suitable for use in areas where flammable gasses or vapours are present. Therefore, remove the mains plug from the socket before the area in which the equipment is located is disinfected, since some disinfection solutions evaporate and subsequently form an explosive mixture.

1.2.3 Operational safety

- Using the equipment in the vicinity of short wave or microwave equipment can influence the output of the unit. Using this equipment when high frequency surgical equipment is connected to the patient at the same time can result in burning under the electrodes.
- Patients who have electrical implants (i.e. pacemaker) may only be treated following medical advice.
- Laser beams are dangerous for the eyes. You must ensure that the laser beams do not reach the eyes. In cases where the risk of laser beams reaching the eyes is increased, for example when the patient is receiving treatment to the face, then he/she should wear safety glasses. Also, when you are holding the probe at some distance from the skin and there is the possibility of the beam reflecting into the eyes, the patient and the therapist should wear glasses. For other treatment it is advised to wear glasses.
- The equipment is not suitable for use in damp areas.

- A warning sign should be hung on the door to the area in which laser therapy is being applied. The sign should include the laser warning symbol and the text "Attention, laser light is used in the area".
- The equipment may not be disinfected or sterilized.
- The equipment contains a number of safety systems which operate independently of the microprocessor.
  When the safety system detects a fault during electrotherapy the delivery of current is interrupted within a few milliseconds and it is impossible to perform treatment using the equipment. The safety of the patient is therefore guaranteed. Whenever the equipment is switched on (using the main switch) the microprocessor checks the entire safety system for correct operation.

1.2.4 Use of the appliance

The equipment and accessories should only be used by authorized personnel and in accordance with all instructions included in these operating instructions.
The Phyaction 796 is only to be used for laser, ultrasound and/or electrotherapy. The Phyaction 792 is only to be used for ultrasound and/or electrotherapy.

1.2.5 Radio interference suppression and electromagnetic compatibility

This equipment meets the guidelines for ISM equipment relating to electromagnetic compatibility and is radio interference suppressed according to VDE 0871-B. Also see paragraph 1.2.3 *Operational safety*, concerning the use of the equipment in the vicinity of short wave and microwave equipment.

1.3 Installation

1.3.1 Incoming inspection

Check that the equipment, ultrasound head(s) and laser probe(s) have not been damaged during transportation and that the accessories are intact and complete (see chapter 21 ACCESSORIES of the INSTRUCTIONS FOR USE). In the event of damage and/or defect you should inform your supplier.

1.3.2 Mains voltage

Your equipment is suitable for a nominal voltage of 110, 120, 220 or 240 Volt AC, 50-60 Hz. Indicated on the rear of the equipment will be the voltage for which it has been wired. You can not alter this yourself. Carefully check this data before you place the mains plug in the socket. The mains input is on the rear of the equipment.

1.3.3 Functional test

During production the equipment is tested for electrical safety. Whenever the equipment is switched on, the processor performs an extensive test to ensure that the equipment is operating correctly. In addition you must check whether the display and the indicator lamps are operating correctly. If this is not the case, then you must not use the equipment and you must contact your supplier.
If you can not read or if it is difficult to read the display, then press the right hand blue button and the black ⮝ button in order to darken the text or the black ⮟ button if you want to make the text lighter.

1.3.4 Selecting the operating language

You have the possibility to change the operating language by depressing the left hand yellow button and

holding it down until the STANDARD SETTINGS menu appears. You have the choice from various languages. Once selected, the equipment will use the language you have chosen.

1.3.5 Location and transportation

The equipment must be set up horizontally and stable. You must ensure that the perforated sections on both sides of the casing are not covered up, thus hindering air circulation. Objects must not be placed on the equipment and you must ensure that no liquid enters the equipment.

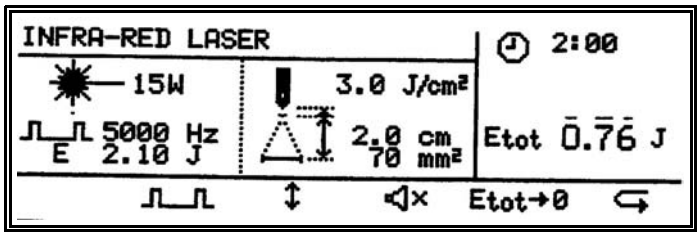
1.4 Description of the controls

On the last page of this service manual you will find an illustration of the equipment and the accessories.

1.4.1 Display

The display[1] consists of separate picture elements which are controlled by a processor so that you can see text and figures. When you are performing a treatment, the display shows all of the information you require:

- Top left is the name of the therapy form. For combination therapy you will find the names of the two selected therapy forms here.
- The central section provides information about the parameters.
- The right-hand section provides information about the output current during electrotherapy, the power emitted during ultrasound therapy and the energy emitted at that moment for laser therapy. For ultrasound combination therapy with a current form, the right-hand section provides the information mentioned above for both selected forms of therapy. Additionally, this section also provides information regarding the therapy time.
- The bottom line of the display shows the functions of the blue buttons.



L*ay out of the display*

1.4.2 Signal lights

In the centre of the panel you will find three coloured lights:

- The green lamp[2] shows that the equipment is connected to the mains and is switched on.
- The yellow lamp[3] provides information during electrotherapy regarding stimulation. For medium frequency surge current it shows the stimulus time, for current forms with frequency modulation it shows the time during which the frequency is low, in other words, when the current form is the most sensitive.
- The red lamp[4] illuminates when the safety system has detected a fault that causes the equipment to be non-operational. A message appears on the display.

The yellow lamps[5] beside the output connectors for the ultrasound heads and the laser probes illuminate respectively as soon as ultrasound or infra-red power is emitted. The yellow lamp beside the current output[6] illuminates as soon as 5mA$_{eff}$ of current is exceeded.

1.4.3 Infra-red sensor

Infra-red laser beams are invisible. In order to check that the laser probe is operating correctly, a sensor[7] is built in. This sensor is located to the right above the current output socket. Using application no. 903 the infra-red laser power can be tested. If the laser probe is held in front of the sensor, the measured peak power will appear on the display. We advise you to perform such a measurement periodically, for example monthly. When performing a treatment using laser therapy, the infra-red sensor can be used to test whether laser energy is being emitted through the probe.

1.4.4 Knobs

On the front and to the right there are three potentiometers. When you turn these knobs fully anti-clockwise, you will detect a click indicating that they are in the zero position. From the top to the bottom the knobs have the following functions:

- Using the top knob[8] you can adjust the laser energy in Joules. The treatment time changes automatically.
- The middle knob[9] is used to adjust the peak intensity in Watt/cm^2 for ultrasound.
- The bottom knob[10] is the dose regulator for electrotherapy.

1.4.5 Push-buttons

- The blue buttons[11] have a function which is different for each program and each menu. The display indicates clearly whether the buttons have a function and, if so, which function.
- The black buttons ▲ or ▼[12] are used to increase or decrease the value of a parameter which you have previously selected.
- The left hand yellow button[13] is used to return to the main menu. If you hold down this button for a few seconds you will arrive in a special menu STANDARD SETTINGS.
- Once you have selected a program, the right hand yellow button[14] quickly and easily provides you with further options of the selected program. Using this button you can call up the applications from the main menu.
- Using the green button[15] you can call up the special memory function. You can store, retrieve and change 250 different treatments.

1.4.6 Output connectors and sockets on the front

The equipment is fitted with a number of connectors for the following functions:

- The two connectors[16] on the far left are used to connect the laser probe(s). It does not matter to which of the two connectors the laser probe(s) is/are connected.
- The two middle connectors[17] are for connecting the ultrasound head(s). Here too it makes no difference to which connector the head(s) is/are connected. You can connect two heads at the same time.
- The two safety sockets[18] on the far right are used for connecting the electrode cables during electrotherapy. For combination therapy you can only use the socket on the far right, since in this case the other socket is without current. In this case the metal treatment surface of the ultrasound head forms the other electrode.

1.4.7 Key switch

When you want to switch on a program utilizing laser, you should turn the key switch[19] to the right. To

switch off, turn the key to the left. To prevent the use of laser by unauthorized personnel, you should remove the key from the equipment when it is not being used.

1.4.8 Operating elements on the rear of the equipment

The following operating elements are located on the rear of the equipment:
- Mains input with main switch[20].
- Fuse holder[21] between the mains input and the main switch. The rating of the fuse to be used is stated on the rear of the unit.
- The serial in- and output[22]. These are for future extensions.
- Connector for potential mains equalisation[23].
- Label with equipment data[24].

1.4.9 Laser probes

Various laser probes[25] can be supplied. When you have two probes, these can be connected to your equipment at the same time. Using a blue button you select from the program which probe you wish to use. A green lamp[26] then illuminates on the selected probe. On the probe is a knob[27], which has to be pressed to allow laser light to be emitted. When laser light is being emitted, the yellow lamp[28] on the probe illuminates. For reasons of patient safety and correct operation of the equipment, the connection of probes other than those supplied by Uniphy is not permitted.
If in doubt about the proper operation of your laser probe, you can check this by using technical application no. 903.

Looking into the probe when laser light is being emitted can seriously damage the eyes. Therefore, never look into the laser probe and never point it towards the eyes.

1.4.10 Ultrasound treatment heads

You have the choice of three ultrasound heads[29] with an ERA (Effective Radiation Area) of respectively 1, 4 or 10 cm^2. For each treatment head a multi-functional head holder[30] is supplied. With each treatment head both 1 and 3 MHz ultrasound can be given. Two treatment heads can be connected to the equipment at the same time, provided the treatment heads do not have the same format. Using one of the blue buttons you select which of the two heads you wish to use. A green lamp[31] illuminates on the treatment head as soon as it has been selected and a red lamp[23] illuminates when the surface of the head makes insufficient contact with the patient. The ultrasound power is then automatically adjusted back so that overheating and subsequent wear of the treatment head is prevented. During insufficient contact the treatment time also stops and when contact is made it continues. In this way the set time is actually utilized.
Before using a new treatment head a one-off operation should be performed, using technical application no. 902, to tune your equipment to the treatment head.

1.5 Technical specifications

The Phyaction 790-series consists of two models: the Phyaction 792 and 796. The same specifications for the Phyaction 796 also apply to the Phyaction 792, however, the 792 model is not fitted with an IR-laser.

1.5.1 Ultrasound therapy

General:
- Duty-cycle adjustable from 1:1 up to 1:15
- Power setting using potentiometer
- The unit calculates the total effective power and displays it on the LCD
- Option to tune the ultrasound head to the unit using a special program
- Option of combination therapy using one of the 4 options with electrotherapy current forms
- For each head a green lamp illuminates as soon as the head is selected
- During insufficient contact the ultrasound power is automatically reduced and a red lamp illuminates on the head. The timer stops
- Reflected waves are partially absorbed by the heads to avoid intensity peaks

Specifications small treatment head (model 291):
- Frequencies: 0.8 MHz and 3.3 MHz
- BNR at 0.8 MHz: < 5
- BNR at 3.3 MHz: < 4
- ERA: 1 cm^2
- Output power: 0 - 1.5 W/cm^2 at 3.3 MHz continuous
  0 - 2 W/cm^2 at 0.8 MHz continuous
  0 - 3 W/cm^2 at 0.8 and 3.3 MHz pulsed

Specifications large treatment head (model 292):
- Frequencies: 0.8 MHz and 3.3 MHz
- BNR at 0.8 MHz: < 5
- BNR at 3.3 MHz: < 4
- ERA: 4 cm^2
- Output power: 0 - 1.5 W/cm^2 at 3.3 MHz continuous
  0 - 2 W/cm^2 at 0.8 MHz continuous
  0 - 3 W/cm^2 at 0.8 and 3.3 MHz pulsed

Specifications extra large treatment head (model 293):
- Frequencies: 1.0 MHz and 3.4 MHz
- BNR at 1.0 MHz: < 5
- BNR at 3.4 MHz: < 4
- ERA: 10 cm^2
- Output power: 0 - 1 W/cm^2 at 1.0 and 3.4 MHz continuous
  0 - 1.5 W/cm^2 at 1.0 and 3.4 MHz pulsed

1.5.2 Laser therapy

General:
- Pulse repetition frequency 2 - 5000 Hz
- Energy adjustable with potentiometer
- Operating distance 0 - 5 cm (for energy density calculation)
- Conversion of energy to energy density with given operating distance and calculation of treatment area
- Test eye for checking power of the laser
- A green lamp illuminates when probe is selected and yellow lamp when probe emits energy
- Prior to accessing the laser program the key on the unit should be turned

Specifications 15 W probe (model 241):
- Peak power: minimum 12 W, maximum 18 W
- Max. average power: 12 mW
- Wave length: 904 nm (infrared)
- Laser class: 3B

- Pulse duration: 150 ns
- Beam diameter: 2.5 mm
- Divergence angle: approx. 20 degrees
- Dimensions: diameter 2.5 cm, length 21 cm

Specifications 25 W probe (model 242):
- Peak power: minimum 22 W, maximum 30 W
- Max. average power: 25 mW
- Wave length: 904 nm (infrared)
- Laser class: 3B
- Pulse duration: 200 ns
- Beam diameter: 4.0 mm
- Divergence angle: approx. 32 degrees
- Dimensions: diameter 2.5 cm, length 21 cm

Specifications 4x18 W probe (model 245):
- Peak power per diode: minimum 16 W, maximum 22 W
- Max. average power: 60 mW
- Wave length: 904 nm (infrared)
- Laser class: 3B
- Pulse duration: 150 ns
- Beam diameter: 4 x 2.5 mm
- Homogeneous intensity: from appr. 3 cm from the probe
- Divergence angle: approx. 20 degrees
- Dimensions: diameter 4 cm, length 22 cm

1.5.3 Electrotherapy

Parameters two-pole interferential current:
- Carrier wave frequency: 4000 Hz
- AMF: 1 - 200 Hz
- Spectrum: 0 - 200 Hz
- Time: 1 - 100 s
- Contour: 1 - 100%
- Output current: 140 mA_{peak} maximum at 500 Ohm

Parameters, medium frequency surge current:
- Carrier wave frequency: 4000 Hz
- AMF: 1 - 200 Hz
- Stimulation time: 1 - 100 s
- Pause: 1 - 100 s
- Surge: 1 - 100%
- Output current: 140 mA_{peak} maximum at 500 Ohm
- Choose from automatic or manual stimulation using pulsator

Parameters TENS current, continuous:
- Pulse time: 10 - 300 µs
- Pulse frequency: 1 - 500 Hz
- Spectrum: 0 - 200 Hz
- Time: 1 - 100 s
- Contour: 1 - 100%
- Output current: 140 mA_{peak} at 500 Ohm
- Pulse form: asymmetrical

Parameters TENS current, burst:
- Pulse time: 10 - 300 µs
- Pulse frequency: 80 - 500 Hz

- Burst frequency: 1 - 10 Hz
- Number of pulses per burst: 5
- Output current: 140 mA_{peak} maximum at 500 Ohm
- Pulse form: asymmetrical

TENS current, surge (Phyaction 793 only):
- Pulse time: 10 - 300 µs
- Pulse frequency: 1 - 500 Hz
- Train duration: 1 - 100 s
- Train interval: 1 - 100 s
- Surge: 1 - 100%
- Output current: 140 mA_{peak} at 500 Ohm (at a pulse time up to 100 µs)
- Pulse form: asymmetrical

Continuous galvanic current (Phyaction 793 only):
- Output current: 80 mA_{peak} at 500 Ohm

Interrupted galvanic current, rectangular or triangular pulse (Phyaction 793 only):
- Pulse time: 0.1 - 1000 ms
- Pause time: 2 - 9999 ms
- Output current: 80 mA_{peak} at 500 Ohm

Faradic current, rectangular or triangular pulses (Phyaction 793 only):
- Pulse time: 0.1 - 1000 ms
- Pause time: 2 - 9999 ms
- Train duration: 0.05 - 100 s
- Train interval: 0.05 - 100 s
- Surge: 1 - 100%
- Output current: 80 mA_{peak} at 500 Ohm

Ultra Reiz current (Phyaction 793 only):
- Pulse time: 2 ms
- Pause time: 5 ms
- Output current: 80 mA_{peak} at 500 Ohm

Diadynamic currents MF, DF, CP, CP-ISO, LP (Phyaction 793 only):
- MF frequency: 5 - 200 Hz
- DF frequency: 2 x MF frequency
- MF time: 1 - 100 s
- DF time: 1 - 100 s
- Surge: 1 - 100%
- Output current: 80 mA_{peak} at 500 Ohm

1.5.4 Further details

- Fully programmable memory with space for up to 250 treatment procedures and with battery back-up
- Many recommended programs for simple application per indication
- You can set different operating languages yourself: Dutch, English, German, French, Italian and Spanish
- Pre-programmed parameters can be changed to your requirements
- Treatment time adjustable to 30 minutes

- Acoustic monitor with volume control can be switched on
- Serial input and output for extensions
- Built-in electrode and cable test
- Solid metal casing (Faraday's cage)
- Ergonomically designed with very attractive appearance
- Simple to operate due to clear symbols and the availability of different languages on the display
- Dimensions: 41 x 28 x 13 cm
- Weight Phyaction 796: 6.5 kg (excluding accessories and packing)
  Phyaction 740: 5.7 kg (excluding accessories and packing)
- Insulation class (790 series): I, type BF
  Phyaction 740: I, type B
- Voltage: 110, 220, 230 or 240 Volt, 50-60 Hz
- Input current (790 series): maximum 300 mA_{eff} at 230 V and 600 mA_{eff} at 110 V
  Phyaction 740: maximum 150 mA_{eff} at 230 V and 300 mA_{eff} at 110 V

1.6 Explanation of symbols

1.6.1 General

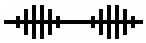
Indication of treatment time

Contrast

1.6.2 Electrotherapy

Output current

Two pole MF current


MF surge current

Biphasic current, continuous

Biphasic current, burst

1.6.3 Electrotherapy, parameter adjustments

Contour

Pulse time biphasic current

Frequency of biphasic current

Burst frequency of biphasic current

Stimulation time with MF surge current

Stimulation interval with MF surge current

Timing clock

Sound signal on/off

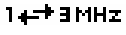
1.6.4 Ultrasound therapy

Selected ultrasound head, small, large, extra large

Duty-cycle

1.6.5 Ultrasound therapy, parameter adjustments

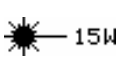
Selectable ultrasound head, small, large, extra large

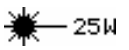
 Toggle ultrasound frequency

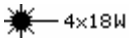
Duty-cycle

Timing clock

1.6.6 Laser therapy

 Laser probe, 15W

 Laser probe 25 W

 Laser probe 4 x 18 W

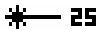
Pulse repetition frequency

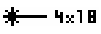
Turn key clockwise

Turn key anti-clockwise

1.6.7 Laser therapy, parameter adjustments

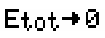
Selectable laser probe, 15W

 Selectable laser probe, 25 W

 Selectable laser probe, 4 x 18 W

Pulse repetition frequency

Distance between laser probe and skin

 Set total energy to zero

Repeat function

Sound signal on/off

1.6.8 Treatment memory

Programmable memory

Store a therapy

Start a stored therapy

Clear a stored therapy

Information memory usage

1.6.9 Symbols on the front of the appliance

Memory function

Return to main menu

Options for this program

Raising the selected parameter

Lowering the selected parameter

Indication light for Stand-by

Indication light for stimulus

Indication light for detected errors

Current

"OFF" for a part of equipment

"ON" for a part of equipment

Laser

Ultrasound

Sensor for laser power measurement

Attention, see manual

1.6.10 Symbols on the back of the appliance

Off

On

Fuse

Serial in- and output

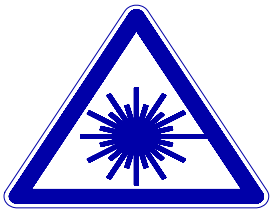
Equipotentiality

Type BF

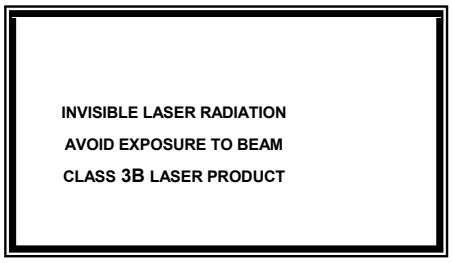
Do not open

Attention, see manual

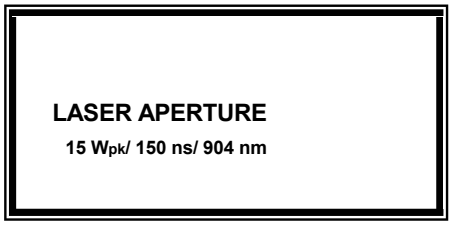
1.6.11 Laser, warning symbol and explanatory labels



Laser warning symbol; on every laser probe

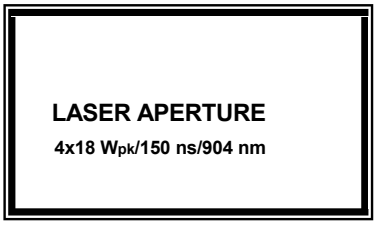


Explanatory label; on every laser probe



Explanatory label; on laser probe model 241

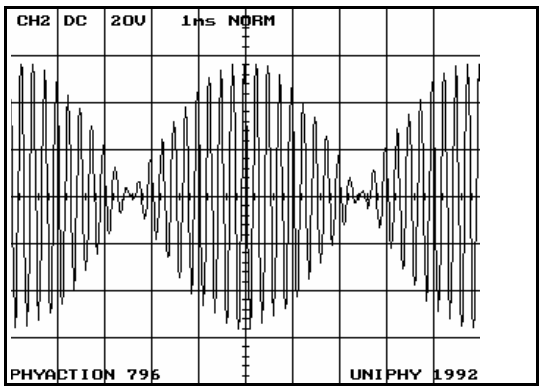
Explanatory label; on laser probe model 242



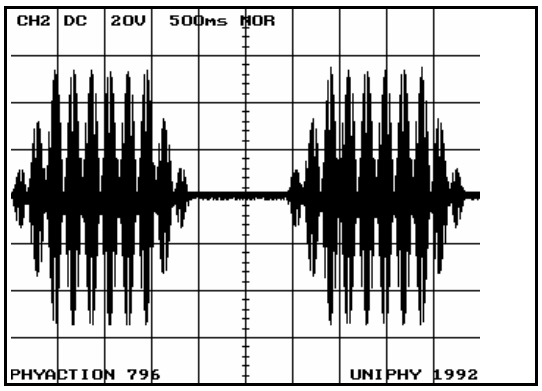
Explanatory label; on laser probe model 245

Type B

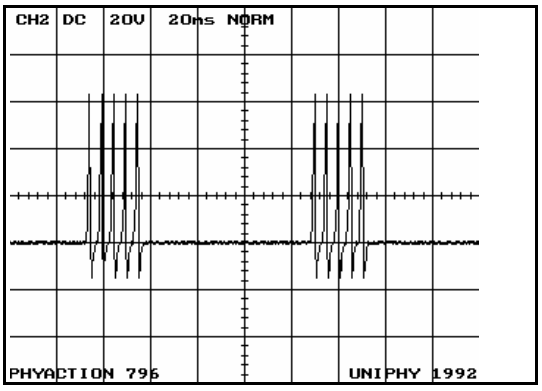
1.7 Photos of the current waveforms



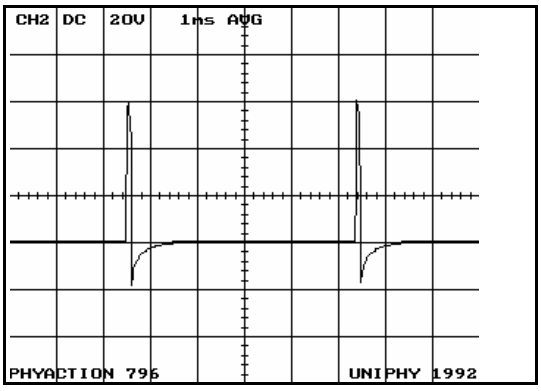
Two pole interference



MF surge current



Biphasic current, burst



Biphasic current, continuous

CHAPTER 2 THEORY OF OPERATION

2.1 Introduction

In this chapter a description of the electronic construction of the Phyaction 790-series is given on the functional level. Only where safety aspects are concerned we will look into the actual circuitry. The next paragraph deals with the whole appliance and those blocks that are in use with all therapies. In the subsequent paragraphs more detailed block diagrams for each kind of therapy will be discussed.

2.2 General block diagram

Figure 1 shows the functional blocks of the Phyaction 797VIP. The most extensive appliance of the series. The microcontroller core controlling the entire appliance is featured in the middle. Immediately below that are the blocks associated with the three therapies and the output panel. At the left there is the user interface and at the right the serial interface. In the upper part there is the inevitable power supply. The parallel interface which is only present in the VIP versions is also drawn here.

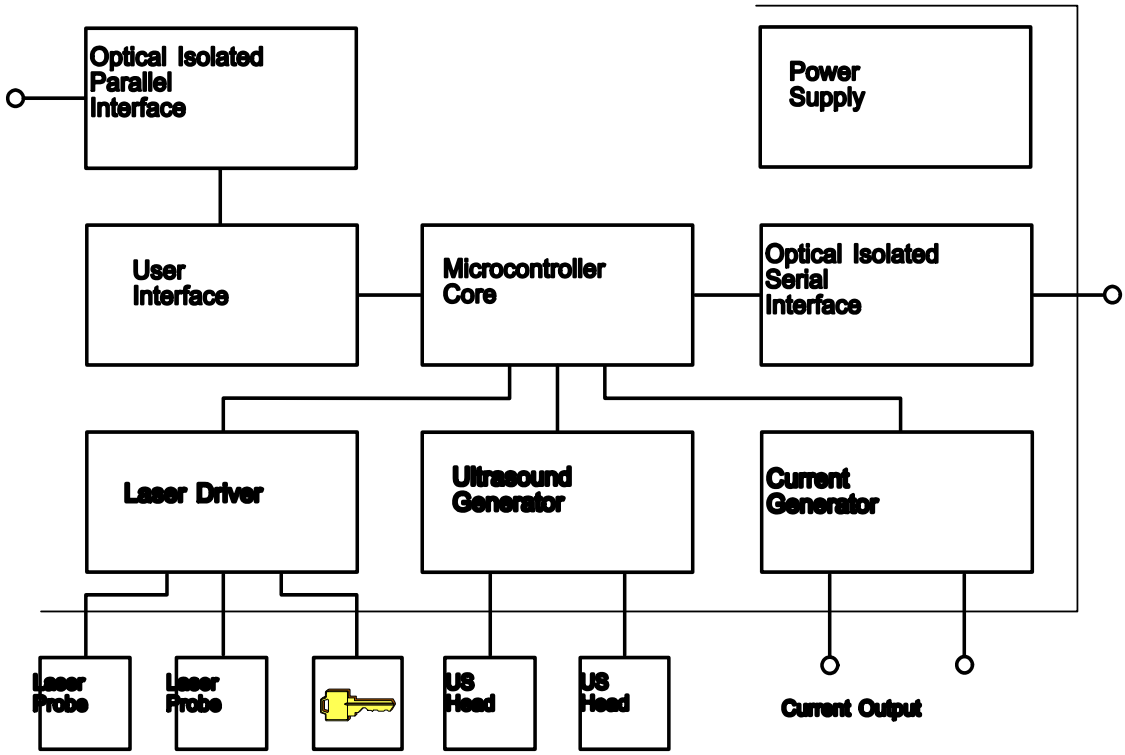


Figure 1, Functional blocks of the Phyaction 797VIP

2.2.1 Microcontroller core

As central processing unit a microcontroller is being used in favour of a microprocessor. The reason being that a microcontroller, by its construction and available commands, is particularly suited for bit-level operations. From the software point of view there is no difference but it is much easier to manipulate a single I/O-pin. The microcontroller used in the Phyaction 790-series is the 80C552. It incorporates in addition to the actual 8051 controller the following circuits:

- 256 Byte RAM
- 3 programmable timers
- 1 A/D-Convertor with eight multiplexed inputs and 10-bits resolution
- 5 I/O ports, each 8 bits wide
- 2 Pulse width modulators with 8-bits resolution
- 1 I²C-bus interface for internal data transmission
- 1 full-duplex UART (Universal Asynchronous Receiver and Transmitter)
- 1 Watchdog timer

Apart from this microcontroller the core contains the following devices:

- an 8-kbyte RAM with integrated lithium battery (NOVRAM)
- a 1-Mbit EPROM
- a programmable I/O-expander
- an analog multiplexer to increase the amount of ADC inputs
- some PAL's and HCMOS chips as decoders and buffers

2.2.2 User interface

A LCD (Liquid Crystal Display) with a console forms the major link in the communication between the operator and the microcontroller. The display is connected directly to the microcontroller via the data-bus and the keys of the console via the I²C-bus. The menus and program screens are shown on the display and the operator selects the requested therapy with the buttons and also changes or enters parameter settings with them.

2.2.3 Serial interface

A serial interface identical to that in the Phyaction 780-series is provided to be used with future extensions. The way of operating is similar to that of the teletype current loop although the level of the current has been reduced. The interface is fully isolated from the rest of the circuits in the appliance by means of optocouplers with an isolation voltage of 2.5 kV.

2.2.4 Parallel interface

This unit, which is only present in the VIP versions, makes up the link between the LCD and the I/O-card in the PC. Again using optocouplers with an isolation voltage of 2.5 kV to achieve full galvanic isolation, the necessary control-signals are tapped and the data is synchronously stored in a RAM. This RAM in its turn is being asynchronously read by the software running on the PC which subsequently reconstructs the image shown on the LCD.

2.2.5 Power supply

The power supply is of a conventional linear design with a mains transformer for medical devices followed by secondary fuses, bridge rectifiers and smoothing capacitors. From the unstabilised voltages created in this way, the one called +29V is used to supply the power stages for the current generation and the ultrasound generation. The other supply voltages, +24V, +15V, -15V and +5V (Vcc), are stabilised by linear regulators with the latter three in addition being protected from overvoltages by crowbars. A reset signal is issued to the microcontroller when the +5V (Vcc) is beneath the threshold

level for the logic ICs.

2.3 Electrotherapy unit

Figure 2 shows the functional blocks for the electrotherapy unit and the associated safety circuit. These circuits are identical to the ones in the Phyaction 780-series. Just a minor simplification has been made in the setting of the maximum current guarding because for the near future only generation of MF currents and TENS is envisaged. Also as a consequence thereof the current-mode facility and the allied switch-over options in the patient output circuit are not needed for the time being.

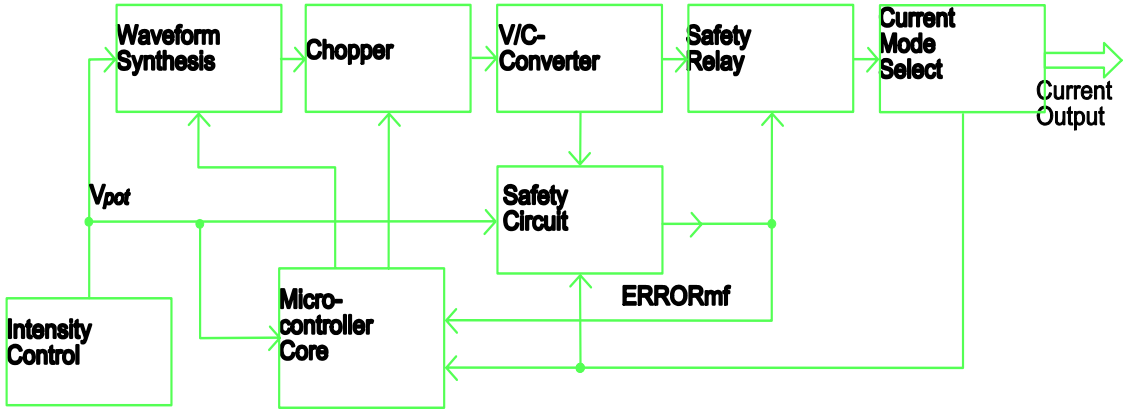


Figure 2, Functional blocks of the electro-therapy unit

2.3.1 Waveform synthesis

The current waveform being selected, the microcontroller accordingly controls the waveform synthesizer to yield the required waveform. The sample data of the waveform are stored in an EPROM and from there transferred to the D/A-converters in the course of the phase. The magnitude of the resulting wave is always proportional to the value of V*pot* being set by the intensity control-knob because it is established by modulating this control-voltage with multiplying D/A-converters.

2.3.2 Chopper

The main purpose of the chopper is to apply the waveform to one of the two inputs of the V/C-converter and to establish in this way the polarity. With TENS the pulses are formed directly by activating the chopper to pass its input voltage to one half of the V/C-converter.

In case of rectified current generation the chopper is operated on a substantially higher switch-rate and the output current is rectified before being applied to the patient. The used switching rate yields an unnoticeable current in case of a defective rectifier.

2.3.3 Voltage to current converter

The voltage-to-current-converter (V/C-converter) converts, as the name indicates, the applied input voltage into a linear proportional output-current. As it is conceived as a balanced stage it is easy to determine the polarity of the output current by applying the controlling voltage to one of the two inputs. The primary output current flows through a low-ohmic resistor. The voltage drop across this resistor is proportional to the absolute magnitude of the actually generated output current and is fed to the safety circuit.

In order to reduce the power dissipation in the actual V/C-converter it is powered through a so called tracing series regulator. This regulator lowers the supply voltage to a level that just accommodates the converter.

2.3.4 Safety circuit

The voltage drop sensed in the V/C-converter is used in this circuit to monitor whether the output current oversteps the limits as stated in IEC 601-2-10 or 150% of the set value, whichever is smaller. In addition the intensity control is monitored for interruptions of the ground terminal. This all is achieved fully independent of the microcontroller by comparators that, in case of a fault, switch off the safety relay, which interrupts the patient current circuit. This happens so fast that even in case the full supply voltage is suddenly applied to one of the primary windings of the output transformer, the energy contents of the resulting pulse will be well below the allowed limit. Once the safety relay has been switched off it remains in this state and one must switch on the appliance after the cause has been removed, e.g. turned up intensity control at switch-on.

Because on switch-on of the appliance a selftest is performed which of course includes a test of the safety circuit, a way is provided for the microcontroller to switch on the safety relay. This is necessary as the safety relay will be in the off state after switch-on and should also switch off a couple of times in the course of the selftest. This possibility to switch on the safety relay is time limited however to 3 seconds from power-on. When this time has expired the microcontroller only can switch off the safety relay, e.g. when an error of another nature has been detected. In this way it is guaranteed for the safety circuit to operate independently from the generation of the patient current and the software.

2.3.5 Current mode selection

As mentioned before it is also possible to generate rectified currents like diadynamic, Ultra Reiz, galvanic, etcetera. To that object a rectifier is switched into the patient current circuit. The choice between rectified and alternating currents is also sensed by the microcontroller to select the adherent set of waveform options and waveform synthesizer control-signals. The rectifier circuit is only present in the Phyaction 793.

2.4 Ultrasound therapy unit

Figure 3 shows the functional blocks for the ultrasound therapy unit. As the ultrasound power is generated by switching, it appeared to be necessary to encapsulate the committed circuitry, from the PLL (Phased Locked Loop) up to the impedance match and including the SSMPS (Secondary Switch Mode Power Supply), in a tin case to meet the emission-limit requirements. This shielding extends itself over the inner shield conductor of the treatment head cable up to the transducer which is mounted in a closed aluminum cylinder.

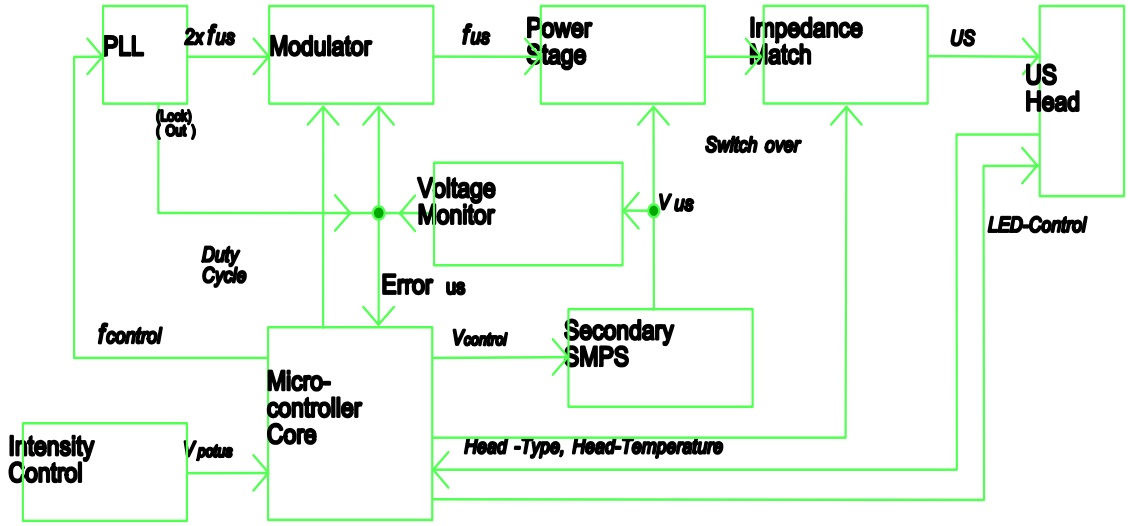


Figure 3, Functional blocks of the ultrasound therapy unit

Settings of parameters as duty cycle, treatment time and frequency, 1 or 3 MHz resp., is done over the user interface. The microcontroller determines the precise operating frequency for the selected treatment head, based upon the identification codes that have been entered during installation of this treatment head. These codes are also used to assess the emitted amount of ultrasound power. The microcontroller also counts down the treatment timer, which it will halt when the emission of ultrasound power is interrupted during the treatment. The operator sets the required ultrasound intensity with the control-knob of the same name. The microcontroller uses the control-voltage V_{potus} together with the identifying codes and the type of the selected treatment head to calculate $V_{control}$ which is fed to the SSMPS in order to generate the requested amount of ultrasound power. The momentary output power converted by the duty cycle is shown on the display as effective output power.

2.4.1 PLL

Because the microcontroller is not capable of generating the drive frequency directly, a PLL (Phased Locked Loop) is used to convert the low-frequency control-signal $f_{control}$ to the drive frequency $2xf_{us}$ needed. Like the description suggests, this frequency is a twofold of the ultrasound-frequency because it gets divided by two in the modulator. As there are two operating areas for the ultrasound-frequency, about 0.8 and 3.3 MHz respectively, and the control-signal $f_{control}$ always is lying about 400 Hz, the feedback loop of the PLL is closed via a divider whose divisor is switched together with the oscillator range. To prevent operation on faulty ultrasound-frequencies, e.g. in absence of the $f_{control}$ signal, a lock-out monitor has been provided whose output is wired-orred with $Error_{us}$.

2.4.2 Modulator

The modulator switches its outputs with half the rate of the drive frequency $2xf_{us}$ to achieve an exactly symmetrical driving of the power stage. The duty cycle signal is used to switch off synchronously both outputs in order to prevent any 'misfirings'. As a result the ultrasound output-signal is completely switched on and off (CW modulation). $Error_{us}$ forms another way to switch off the outputs asynchronously in case of a fault.

2.4.3 Secondary switch mode power supply

This is a regular down-converter powered by the +29V supply. The only peculiarity being that its output voltage is controllable by $V_{control}$. In this way the microcontroller can set the ultrasound power by setting $V_{control}$ proportional to the square-root of the required power.

2.4.4 Power stage

The power stage is a balanced switched half-bridge. It is supplied by the SSMPS mentioned above to control the momentary output power. The switching operation being controlled by the modulator as described above. The switches are formed by power-MOSFETs driven from buffers that insert a switch-on gap to prevent both sides from conducting simultaneously.

2.4.5 Impedance matching

The nature of the load of the transducers in the treatment head is essentially capacitive and varies with the surface area and the operating frequency. Therefore a collection of inductors and capacitors is available from which the microcontroller inserts the required combination for the selected type of the treatment head and operating frequency.

2.4.6 Ultrasound treatment head

The most important part is of course the transducer, a piezoelectric crystal with a surface area appropriate for the type of treatment head. This piezoelectric crystal is mounted on the base of an aluminum cylinder, with the thickness of the base enabling it to use two considerably different operating frequencies. The aluminum cylinder also functions as the second electrode for the patient current when applying combined therapy. A temperature sensor is mounted on the other end of the cylinder to monitor the temperature of the treatment surface. The type of the treatment head is encoded by a resistance value. Also provided are LED-lamps for signalling purposes. A green colour signals the treatment head being stand-by or in normal operation and a red colour signals an interruption of the treatment because of overheating of the treatment surface or insufficient acoustical contact. The LED-lamps are driven by a single conductor by controlling the direction of the current.

2.4.7 Safety circuit

As described above a lock-out of the PLL will force the modulator to switch off. The supply voltage of the power stage is also monitored for voltages beyond the intended operating range. This is done independently from the microcontroller as it senses this voltage already to adjust $V_{control}$ for tolerances in the SSMPS. The resulting $Error_{US}$ signal inhibits the modulator and is also sent to the microcontroller. The $Error_{US}$ signal can also be activated the other way round by the microcontroller if it detects another error.

2.5 Infrared laser unit

The circuit for infrared laser therapy consists of two main parts. The part that delivers the actual laser pulse is located in the laser probe. The control-circuit and the measuring facility are in the base appliance. Only with the switchlock turned on the power supply is connected to the laser probe and the I/O-buffers. This warrants the operational safety as it is therefore impossible to release laser radiation without using the key.

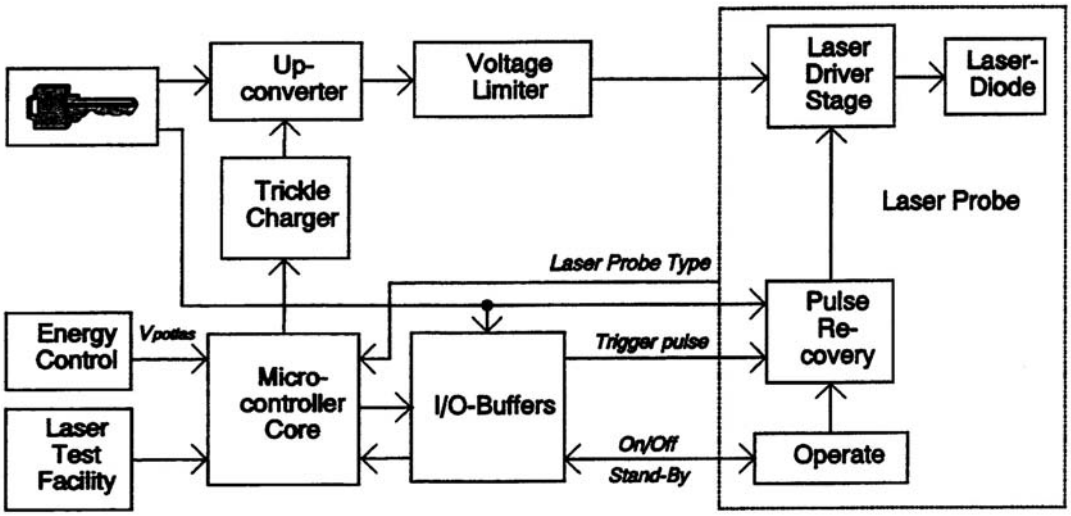


Figure 4, Functional blocks of the infrared laser therapy unit

The microcontroller controls the laser probes through the I/O-buffers. The operator sets with the energy control-knob the amount of energy that has to be delivered. The microcontroller converts this, depending on the selected repetition rate, distance to the surface to be treated and the laser probe being employed (= type of laser), into energy per square centimetre and required treatment time. These three parameters are simultaneously evaluated and shown on the display whilst the energy control-knob is being operated. When the pushbutton on the laser probe is depressed, the microcontroller issues trigger pulses to the laser probe and calculates how much energy has been delivered. The triggering stops if this has accumulated to the same amount of energy as being set.

2.5.1 Putting into operation

Pressing the pushbutton on the laser probe starts the issue of trigger pulses and switches over the signal lamps provided that the laser stand-by line is active. Only with the pushbutton being depressed the trigger pulses can reach the pulse recovery circuit.

2.5.2 Pulse recovery

This block consists of a one-shot with its pulse time determining how long the driver switch remains conductive. Triggering with rates higher than can be handled by the laser probe is prevented by a second one-shot that inhibits retriggering while being active.

2.5.3 Laser driver stage

This is basically a capacitor that is being discharged through the laser diode by a switch. Using the appropriate layout yields the current waveform needed. As long as the switch remains conductive the current through the up-converter inductor will increase. At the end of the conductive period determined by one-shot of the pulse recovery this will result in recharging of the capacitor with the energy stored in the inductor.

2.5.4 Trickle charger

At repetition rates below 400 Hz the leakage discharge of the capacitor gets significant so too less energy would remain for the next laser pulse. Therefore this trickle charger which operates in parallel to the switching element in the laser probe periodically restores the energy level between the laser pulses.

2.5.5 Laser test facility

A photo-pindiode is illuminated trough an attenuating window by the laser diode to be measured. The peak value of the resulting diode current is a measure for the intensity of the laser beam. Because the type of the laser diode is known the peak power of the laser pulse can be assessed and shown on the display.

CHAPTER 3 PERFORMANCE CHECK

3.1 Safety inspection

3.1.1 Visual inspection

Passed, when all applicable items are answered with YES.

	yes	no
Is the user manual there?		
Is the casing of the appliance undamaged?		
Is the label well readable?		
Are the controls, display, lights and connectors all right?		
Are the mains input and the equipotentiality busbar all right?		
Are the electrodes, cables and connectors undamaged?		
Are ultrasound therapy, cables and connectors undamaged? (Pay special attention to possible leaks in the treatment heads.)		
Are the labels on the ultrasound treatment heads readable?		
Are the laser probes, cables and connectors undamaged? (Pay attention to scratches on the glass of the laser output (aperture).)		
Are the labels on the laser probes readable?		
Are the laser protection glasses on hand and in good condition?		

3.1.2 Functional test, general

Passed, when all applicable items are answered with YES.

	yes	no
Is the automatic selftest executed successfully at power on?		
Is an error message appearing when the appliance is powered on with the current dose potentiometer turned on?		

3.1.3 Functional test, electrotherapy part

Passed, when all applicable items are answered with YES.

	yes	no
Do the current waveforms and amplitudes correspond with the data in the user manual when measured with an oscilloscope and a 500 Ω load?		
Does the current flow through the right safety connector and the ultrasound treatment head instead of between the two safety connectors when the combination therapy menu is selected?		

3.1.4 Functional test, ultrasound part

Passed, when all applicable items are answered with YES.

		yes	no
Is the appliance adjusted to all treatment heads?	1 cm²		
	4 cm²		
	10 cm²		
Does the ultrasound output correspond with the power displayed on the	1 cm²		
LCD, for both frequencies at maximum intensity?	4 cm²		
	10 cm²		

3.1.5 Functional test, laser part

Passed, when all applicable items are answered with YES.

	yes	no
Does the green light on the probe only burn when the laser is switched on with the key?		
Does the yellow light only burn when the laser is selected and the pushbutton is pressed?		
Is laser light emitted only when the yellow light is burning?		
Is the emitted laser power correct?		
Does the displayed power measured with the laser test cell correspond with the emitted laser power?		

3.1.6 Test of the electrical safety according to VDE 0751

Parameter	Measured value	Limit	Remarks
Protective earth resistance	Ω	< 0,2 Ω	
Enclosure leakage current	µA	< 1000 µA	
Patient leakage current	µA	< 5000 µA	

3.1.7 Dielectric strength test

These tests need only be executed when repairs have been made in the mains part or in the output circuits.

Passed, when all applicable items are answered with YES.

	yes	no
Does the isolation between the enclosure and the mains withstand 1.5 kV_{AC} during 1 minute or 1.8 kV during 1 second? (appliance not switched on.)		
Does the isolation between the enclosure and the current output withstand 1.5 kV_{AC} during 1 second? (appliance not switched on.)		

CHAPTER 4 ADJUSTMENT PROCEDURES

4.1 Introduction

Only the adjustment procedures which can be carried out without special training are described in this manual. Other adjustments should not be carried out because of possible safety hazards.

After any repair or printed circuit board (PCB) swap the performance check (chapter 3) has to be carried out. For repairs on the printed circuit boards themselves it is often necessary to carry at (part of) the PCB adjustment procedures. This can only be carried out by Uniphy Service and Production personnel.

4.2 Adjustment of the dose potentiometer guard circuit

For this adjustment you need a voltmeter (DC, 0.2%) and a small screwdriver. This adjustment has to be carried out every time the main board (PCB 792X) or the control board (PCB 791X) are replaced.

Connect the voltmeter to MP20 (GND) and MP21 (Vdose) on the front PCB (791X). Switch the appliance on. Adjust the voltage measured to 4.51 V ± 0.01 V with P10, while the dosage regulator is in the zero position. When this is done, switch off the appliance and remove the voltmeter cables from the measure points.

4.3 Adjustment of the laser power measuring cell

For this adjustment you will need a calibrated laser probe (model 241 or 242), which can be bought from Uniphy. Uniphy will carry out a yearly calibration if wanted. This adjustment has to be carried out every time the control board (PCB 791X) is exchanged.

Turn P11 maximum counter clockwise. Switch on the device and chose application 903 from application list (push the upper black button twice and then the fourth blue button). Connect your calibrated laser probe and turn the key clockwise. Hold the probe tip perpendicular in the middle of the laser test cell and push the button on the probe. Turn P11 clockwise until the measured peak power matches the power of your calibration laser. The 796 will hold the maximum value measured as long as the button on the probe is pressed. Verify the adjustment by releasing the button for a short instance and checking the measured value.

CHAPTER 5 TROUBLE SHOOTING

5.1 Introduction

In this chapter a description is given of the most common error messages and their probable cause.

The following categories of errors are identified:

- Errors during selftest
- Errors during normal use
- Software errors

With a number of errors a special message is displayed explaining in short what the detected problem is. All other errors are displayed in the following manner (the numbers are just an example and change per error):

```
THE PROCESSOR HAS DETECTED AN ERROR
----------------------------------------
Error number  :                  43
Error code    :                   0
Error value   :                0040h
Error address :                1EF4h
----------------------------------------
```

The error numbers, on the line indicated by "Error number:" are described in paragraph 5.4 and 5.5. The numbers at the "Error code:" and "Error value:" lines give in some occasions additional information about the error. The hexadecimal number on the line "Error address:" indicates the program counter position at the occurrence of the error. This is important in case of software errors. In cases the display is (probably) not available the processor will activate the buzzer a number of times, description also later in this chapter.

The selftest checks proper functioning of the safety relay and circuits and is activated every time the unit is switched on. The tests are performed by the microprocessor and lasts for approximately 3 seconds. The current dosage regulator should be in the zero position (maximum counter clock wise). This is checked at regular intervals during the selftest. If the dosage regulator is not at zero an error will be reported (**ERROR 50**) and an error shutdown procedure will be initiated as described below.

The safety relay driver circuitry is accessible to the microprocessor for 3 seconds after power up of the unit. After this period the microprocessor will not be able to switch the safety relay on any more. The control lines used for test purpose only are only accessible by the microprocessor if the dosage regulator is in the zero position as extra precaution against hard- or software errors.

5.2 Error shutdown procedure

The safety circuit will switch off the safety relay directly in the event of an error, thus disconnecting the output from the unit to external connections to avoid danger to the patient.
In addition to this the microprocessor will, if it detects an error either from the safety circuit or otherwise, perform the following actions:

- Safety relay off: Patient circuit disconnected. This is a latched condition that can only be reversed by switching off the unit.
- Dummy relay off: The output is short circuited. (This can only occur if the current dosage regulator is at zero).
- Choppers off: No signal to the output stage (no output current).
- MF-Dac's to zero: No signal to the choppers
- US-Dac to zero: The power supply of the ultrasound output stage is set to minimum.
- US duty cycle off: The ultrasound modulator will be switched off.
- PB-enable off: The laser probe is switched off.
- Laser drip charger off: The laser power supply is switched off.
- Red error-LED on
- Fan on
- An error message is displayed on the LCD screen. In some cases the yellow monitor-LED is pulsed in case the processor has not established communications with the LCD screen yet.

5.3 General test description

The microprocessor gathers its information via digital and analog inputs and these are tested first. Next the current generator and its safety circuits are tested, then the ultrasound generator and the laser generator. Finally some additional simple tests are performed.

In case the unit does not finish the selftest, no error message is displayed, the buzzer is not pulsed and all internal wiring is connected properly the following items are suspect :

- Supplies (mains and other)
- Microcontroller
- Program EPROM
- Address, data or control lines

5.3.1 Microcontroller core test

Any errors found will stop the selftest and an error message will be displayed.

MICROCONTROLLER TEST

The following tests are performed:

1 MF-Error line check. If the MF-error line is in error condition (safety relay switched off) the buzzer will be activated 7 times (**ERROR 57**).
2 The microcontroller arithmetic and logic unit (ALU) check. The controller executes a number of arithmetic operations and compares the calculated value with the correct value. In case of failure the buzzer will be activated 4 times (**ERROR 20, error code 0**).
3 Test of the internal RAM. The controller writes some data to the internal RAM and compares the data read from the RAM with the original data. In case of failure the buzzer will be activated 4 times (**ERROR 20, error code 1**).
4 Test of the external RAM. The RAM is tested for writeabilty and data retention. This also checks address, data and read/write control lines. Incase of a failure the buzzer will be activated 5 times (**ERROR 22**).

5 Program storage test. By means of a checksum test on the first 32k the data integrity of the program stored in EPROM is tested. In case of a failure the buzzer will be activated 6 times (**ERROR 21**).

With the above tests the operation of the microcontroller is tested.

PERIPHERAL TEST

1 Bank switch circuit. The controller will switch on all banks of the EPROM one by one and check a known value in every bank. Incase of a failure the buzzer will be activated 8 times (**ERROR 28**).
2 LCD display. The controller checks if communications with the display controller can be activated. Incase of a failure the buzzer will be activated 11 times fast (**ERROR 41**).
3 I^2C-bus. The controller checks whether all ICs connected to the I^2C-bus are responding. In case of a failure **ERROR 43**, with error value the I^2C-address of the IC that failed. The order of testing is: ultrasound I/O (U6, address 4Ah), front panel I/O (U101, address 46h), keyboard I/O (U400, address 40h), front panel ADC (U102, address 96h). If the fault occurs with the first address as error value (4Ah), this can mean that this particular IC is failing, the microcontroller is failing or the I^2C-link is broken.
4 Internal timers and the internal ADC. The relation between the timer outputs and the clock frequency is tested and the internal ADC. In case of a failure **ERROR 20**, with error code 3, 4 and 5 for a failure in timer 0, 1 and 2 respectively, error code 6 when the ADC is not busy (ADC not started) and error code 7 when the ADC is not ready (conversion takes to long).
5 8155 (I/O-expander). The RAM of the 8155, the timer and the I/O-registers are tested. In case of a failure **ERROR 31**, with error code 0 for a failure in the RAM, 1 till 3 for the I/O-registers and 4 for the timer.
6 8253 (timer). The 3 timers in this IC are tested, in case of a failure **ERROR 32**, with error code 0, 1 and 2 for timer 0, 1 and 2 respectively.
7 A/D-convertor. An reference voltage (Vref, 2.53 V) is converted and checked against a stored value. A conversion result below 2.39 V or above 2.63 V (ADC-values 01E9h and 021Ah) results in **ERROR 37**, with error value the measured ADC-value.
8 Supply voltages +24V, +15V and -15V through a resistive network. If the summing point of the resistive network is below 1.16 V or above 3.47 V (ADC-values 00EDh and 02C6) **ERROR 53** is reported, with error value the measured ADC-value.
9 Reference voltage of the ultrasound and laser dosage potentiometers. The controller tests the reference voltage of the dosage regulators with the I^2C-ADC. If the voltage is below 3.85 V or above 3.85 (ADC-values 03ADh and 0313h) **ERROR 38** is reported, with error value the measured ADC-value.

With the above tests the microcontroller, peripherals, analog inputs and supply voltages have been tested

5.3.2 Test current generator and safety circuit

TEST OF THE INITIAL STATE

The following tests are performed:

1 MF-Error line check. If the MF-errorline is in error condition (safety relay switched off) **ERROR 57** is reported.
2 Dosage regulator at zero, checked by means of the potentiometer switch. If not at zero **ERROR 50** (check cables if the control is at 0 position).
3 Dosage regulator output signal. This should be at or close to 0 V. A voltage above 0.1 V (ADC-value 0014h) results in **ERROR 54**, with error value the measured ADC-value.

4 Initial voltage on the voltage-to-current-converter (V/C-converter). This voltage should be between

6.1 and 8.0 V (on ADC 1.10 and 1.45 V, ADC-values 00E1 and 0128h). When the voltage is out of range **ERROR 60** is reported, with error value the measured ADC-value.

5 Optocoupler test. The voltage returned from the optocouplers for high resistance check (patient circuit resistance) must be between 3.75 V and 4.25 V (ADC-values 02FFh and 0365h) in case there is no output current set. **ERROR 42** will be generated in case this test fails, with error value the measured ADC-value.

After this test the current generator is initialised:
- the DACs are initialised,
- the choppers are set to 40 kHz,
- waveform table 3 (galvanic x sine) is selected,
- the MF frequency is set to 4 kHz.

SAFETY AND DUMMY RELAY TEST

In the following test sequence the safety and dummy relay's are tested for proper functioning. No external (patient) connection should exist during this test. The DAC is programmed in such a way that with a test reference voltage applied via the TEST line approximately 2 mA will flow through the output circuit, if connected either through an external connection or the dummy relay. The voltage level at the tracing series regulator is proportionate to the resistance in the output (patient) circuit with a given current. This level is used to test the output circuit resistance. A voltage on this point below 10.9 V if checking for an open circuit is recognized as an error. A voltage above 8.25 V while testing for a closed circuit is recognized as error.

When the safety relay is energized (on) the contacts are closed. The dummy relay will short circuit the output channel if in energized (on) state.

1 Test if the safety relay is off. A low current (apr. 2 mA) is applied to the output circuit. If a closed circuit is detected (Vmf < 10.9 V, on ADC 1.97 V, ADC-value 0193h) **ERROR 61** will occur, with error value the measured ADC-value.

2 Test if errorline becomes activated if the safety relay is switched on. If the error line is activated within 10 msec it means that the safety circuit has activated it and **ERROR 55** will occur.

3 Test if the safety relay makes contact. With the safety relay on and the dummy relay on a closed circuit should exist. An open circuit (Vmf > 8.25 V, on ADC 1.49 V, ADC-value 0130h) will result in **ERROR 62**, with error value the measured ADC-value.

4 Test for external (patient) connections. When the dummy relay is switched off the output circuit should be open again. A closed circuit indicates an external connection. **ERROR 63** is reported when Vmf is below 10.9 V (1.97 V on ADC, ADC-value 0193h), with error value the measured ADC-value.

5 Test if dummy relay makes contact. After energizing the dummy relay the outputs should be shorted. If Vmf is above 8.25 V (1.49 V on ADC, ADC-value 0130h) **ERROR 64** occurs, with error value the measured ADC-value.

6 Dosage regulator at zero, checked by means of the potentiometer switch. If not at zero **ERROR 50**.

If these tests have passed the safety and dummy relay are functioning and no external connections exist. In the next test the safety relay is tested under full load conditions. The DAC's are programmed for an output current of 110% maximum operating current. At the moment the safety relay is closed the safety circuit should become active immediately, because the dose regulator is in the zero position.

1 Test if the safety relay switches under full load. When the safety relay is switched on, the safety limit check circuits should activate the errorline causing the safety relay to drop off. If the errorline

is not activated within 40 msec **ERROR 65** is generated, with error code 0.

2 Test if the safety relay contacts open. If the above test passes but a closed circuit is detected (Vmf below 20.7 V, on ADC 3.73 V, ADC-value 02FBh) the same error is generated, **ERROR 65**. This time the error code is 1 and the error value the measured ADC-value.

This test completes the verification of the safety relay.

150% SAFETY LIMIT CHECK

In this test sequence the 150% comparator circuits are tested. The safety relay is energized and a closed output circuit is created by switching on the dummy relay. By programming the DAC two currents are generated one representing a value below 150% (1.5 mA) and one above 150% (8 mA). The limit checks are done on each half of the output stage.

1 Test with a current below 150% whether no error condition is generated. If the errorline is activated **ERROR 66** is reported, with error code 0.
2 Test one half of the safety circuit (comparator 1) for 150% limit. If the errorline is not activated with the 150% current **ERROR 66** is generated, with error code 1.
3 Test the other half of the safety circuit (comparator 2) for 150% limit. The error messages is also **ERROR 66**, with error code 2.

This completes the verification of the 150% limit check circuits.

MAXIMUM CURRENT SAFETY LIMIT CHECK

This comparator checks for currents above the maximum allowable output current and should report an error if the output current rises above 110% of the maximum allowable. The maximum current is simulated by test lines connected to the comparator network.

1 Simulate normal current with test lines TST2. If the errorline is activated **ERROR 67** will be generated, with error code 0. This also checks whether the 11 kΩ input resistors are installed.
2 Simulate 110% current with TST1. If the errorline is not activated **ERROR 67** is generated, with error code 1.

This completes the maximum current safety limit check.

OTHER TESTS OF THE CURRENT GENERATOR

1 Test of the dose regulator guard circuit. Test line TST0 is activated, if the errorline is not activated within 3 msec **ERROR 56** is generated.
2 Dosage regulator at zero, checked by means of the potentiometer switch. If not at zero **ERROR 50**.

After these tests all test lines deactivated, the short circuit relay is switched off and the safety relay on.

5.3.3 Test ultrasound generator

TEST OF THE HEAD TYPES

The microcontroller verifies whether the voltages indicating the type of ultrasound treatment head connected are within the following ranges:

Small head:	0.88 .. 1.48V,	ADC-value: 00B4h .. 012Eh
Large head:	2.20 .. 2.80V,	ADC-value: 01C2h .. 023Ch
Extra large head:	3.48 .. 4.08V,	ADC-value: 03EAh .. 03FFh
No head:	4.90 .. 5.00V,	ADC-value: 03EAh .. 03FFh

If one of the voltages (HDtyp1 or HDtyp2) is not within one of these ranges, **ERROR 70** is generated, with error code 1 or 2 (1 is the left connector, 2 the right connector) and the error value is the measured ADC-value.

TEST OF THE HEAD TEMPERATURE

The microcontroller verifies whether the voltage that indicates the temperature of the treatment head is within the range of 2.16 till 4.08V (ADC-value 01B9h .. 0342h) when a head is connected and 4.96 .. 5.00V (ADC-value 03F6h .. 03FFh) when there is no head connected. When one of the voltages (HDtemp1 or HDtemp2) is out of range, you will get **ERROR 71**, with error code 1 or 2 (1 is the left connector, 2 the right connector) and the error value is the measured ADC-value.

TEST OF THE ULTRASOUND POWER SUPPLY

Test of the minimum supply voltage

The ultrasound DAC is already in the minimum position. The voltage Vsnsus is measured, if this voltage is greater than 0.39V (ADC-value 004Fh) you will get **ERROR 72**, with error code 0.

Test of the maximum supply voltage

The ultrasound DAC is loaded with 235. The voltage Vsnsus should be greater than 4.71V (ADC-value 03C3h) after 40 msec. If not then you will get **ERROR 72**, with error code 255.

Test of the duty-cycle modulator

The duty-cycle is switched off (DC 1:0) and the voltage V_{usi} is measured. When this voltage is above 0.05V **ERROR 74** is generated and the error value is the measured ADC-value.

Test whether the supply voltage decreases fast enough

The ultrasound power supply is set to minimum voltage again with the ultrasound DAC. The ultrasound power stage is switched on to decharge C6 and C7. When the voltage Vsnsus is not decrease below 3.53V (ADC-value 02D2h) within 200 msec you will get **ERROR 72**, with error code 100. There is another delay of 200 msec before the power stage is switched off again.

TEST OF THE ULTRASOUND SAFETY SYSTEM

1 The ultrasound power supply is in the minimum position. When the ultrasound error line (ERRORus) is active you will get **ERROR 73**, with error code 1.

2 The test line (TST4) is activated. When the ultrasound error line (ERRORus) is activated within 5 msec you will get **ERROR 73**, with error code 2. The test line TST4 is deactivated again.

3 The ultrasound power supply voltage (Vddus) is set to 18.2V. Then there is a 20 msec delay to make sure that the supply voltage is stabilised. Then test line TST4 is activated again. When the error line (ERRORus) is activated within 5 msec you will get **ERROR 73**, with error code 3. Again the test line (TST4) is deactivated.

4 The ultrasound power supply voltage (Vddus) is increased to 22.2V. After a delay of 10 msec the test line TST4 is activated. When the error line (ERRORus) is not activated within 5 msec you will get **ERROR 73**, with error code 4.

5 Finally the supply is set to minimum voltage, the test line TST4 is deactivated and the ultrasound power stage is switched on for 100 msec. When the error line (ERRORus) is still active you will get **ERROR 73**, with error code 5.

5.3.4 Test laser generator

TEST OF THE PROBE TYPES

The microcontroller verifies whether the voltages indicating the type of laser probe connected are within the following ranges:

Model 241: 0.43 .. 0.62V, ADC-values 0057h .. 007Eh
Model 242: 0.72 .. 1.03V, ADC-values 0093h .. 00D2h
No probe : 4.90 .. 5.00V, ADC-values 03EAh .. 03FFh

If one of the voltages (PBtyp1 or PBtyp2) is not within one of these ranges, **ERROR 70** will be generated, with error code 1 or 2 (1 is the left connector, 2 the right connector) and the error value is the measured ADC-value.

TEST WHETHER THE LASER IS INACTIVE

When a laser probe is connected, the controller checks whether the key is turned on and the button on the laser probe is pressed as well. In this case **ERROR 81** is generated, with error code 1 or 2 (1 is the left connector, 2 the right connector).

TEST OF THE VOLTAGE OF THE LASER TEST CELL

The controller checks whether the voltage of the laser test cell is below 0.1 V (ADC-value 0014h). If not **ERROR 82** is reported, and the error value is the measured ADC-value.

5.3.5 Other tests

A checksum test of the EPROM is executed for the non-tested banks 1, 2 and 3. If an error is found **ERROR 21** is reported with an error code equivalent to the bank found at fault. The error value is the calculated checksum for the bank concerned.

A test is performed at a specific location of the battery backed up RAM. If the data in this location does not conform with the test value the RAM has lost data. The message following message will be shown:"THE DEFAULT MEMORY IS NOT OK, check the back-up battery, data in memory lost."

Serial bus test. If a test connector (or another serial device), looping the output signal back to the input, is connected to the serial communication port the message: 'Serial device connected' is displayed if the test passes. No message will be displayed if the test fails or if no test connector is installed !!

5.4 Error numbers summary

Software

10	RANGE_ERR	Range error
11	CALL_ERR	Call error
12	TILT_ERR	Tilt error

Microcontroller

20	PROC_ERR	Controller error
21	EPROM_ERR	EPROM checksum error
22	ERAM_ERR	External RAM
28	BANK_ERR	Bankswitch error
29	MEM_ERR	Memory error

Peripherals

31	_8155_ERR	81C55 error
32	_8253_ERR	82C53 error
33	I2C_ERR	I²C error
37	ADC_VREF_ERR	Reference voltage internal ADC error
38	POTREF_ERR	Reference voltage US/LS-dose error
40	ADC_TIMEOUT	ADC time out
41	LCD_TIMEOUT	LCD time out
42	OC_ERR	Optocoupler error
43	I2C_TIMEOUT	I²C time out
44	KEYBOARD_ERR	Keyboard error
45	BININ_ERR	Instable digital signal
49	INT_ILLEGAL	Illegal interrupt

Safety circuit current generator

50	POTMET_ERR	Dose regulator not in 0-position
51	ERRORMF_ERR	MF-errorline active
53	POWER_ERR	Sum supply voltages error
54	POTADC_ERR	Dose regulator voltage not 0 Volt
55	ERRACT_ERR	MF-errorline does not become inactive
56	POTGUARD_ERR	Dose regulator guard circuit error
57	NOERRORMF_ERR	MF-errorline inactive at power-on
58	VTEMP_ERR	Measured temperature too high
59	MFPOT_ERR	Switch of the current intensity control is defective
60	UI_ERR	V/C converter error
61	RELPOS_ERR	Relay in wrong position
62	RELSWITCH_ERR	Relay doesn't switch
63	PAT_ERR	Patient connected
64	SHORT_ERR	Short circuit relay error
65	RELMAX_ERR	Safety relay doesn't operate at max. current
66	LIM150_ERR	150% limit circuit error
67	LIMMAX_ERR	Maximum current limit error

Ultrasound errors

70	HDTYPE_ERR	Unknown head type
71	HDTEMP_ERR	Head temperature error
72	VSNSUS_ERR	Ultrasound power supply error
73	US_ERR	General ultrasound error
74	VUSI_ERR	V_{usi} greater than 0 Volt at duty-cycle 1:0
79	USPOT_ERR	Switch of ultrasound intensity control is defective

Laser errors

80	PBTYPE_ERR	Unknown probe type
81	PBACT_ERR	Probe active
82	LSEYE_ERR	Laser test cell voltage error
83	LS_ERR	General laser error
89	LSPOT_ERR	Switch of laser dosage control is defective

5.5 Error descriptions

Nr	Name	Description	Code	Value	Addr.
1. Software errors					
10	RANGE_ERR	Range error:			
		?	0		
		parameter number	1	parnr	
		command number	2	cmdnr	
		menu number	3	mnunr	
		screen number	4	scrnr	
		window number	5	winnr	
		program number	6	prgnr	
11	CALL_ERR	Call error			
12	TILT_ERR	Tilt error			
2. Microcontroller errors					
20	PROC_ERR	Controller error:			
	4*	cpu	0		
	4*	internal RAM	1		
		internal SFR	2		
		internal timer 0	3	counter	
		internal timer 1	4	counter	
		internal timer 2	5	sample/counter	
		internal ADC not busy	6	ADCON	
		internal ADC not ready	7	ADCON	

Nr	Name	Description	Code	Value	Addr.
21	EPROM_ERR 6*	EPROM checksum error	bank	calculated checksum	
22	ERAM_ERR 5*	external RAM error		error address	
28	BANK_ERR 8*	Bankswitch error	bank	PSW	
29	MEM_ERR	Memory error ? PatMem DefMem SysMem PrgMem	 0 1 2 3 4		

3. Peripherals (during selftest)					
31	_8155_ERR	81C55 error: RAM port A port B port C timer	 0 1 2 3 4	 byte read byte read byte read byte read counter	 error addr.
32	_8253_ERR	82C53 error: timer 0 timer 1 timer 2	 0 1 2	 counter counter counter	
33	I2C_ERR	I²C error: keyboard (KB) front panel (FP) ultrasound (US) dose (DS)		 40h 46h 4Ah 96h	
37	ADC_VREF_ ERR	Reference voltage internal ADC error	0	Vref2 (ADC)	
38	POTREF_ERR	Reference voltage US/LS-dose error		VPOTref (ADC)	

4. Peripherals (during normal operation)					
40	ADC_ TIMEOUT	ADC time out			
41	LCD_ TIMEOUT 11*	LCD time out			
42	OC_ERR	Optocoupler error		OCdet (ADC)	
43	I2C_ TIMEOUT	I²C time out (0=send,1=receive) keyboard (KB) front panel (FP) ultrasound (US) dose (DS)	0/1	 40h 46h 4Ah 96h	
44	KEYBOARD_ ERR	Keyboard error	0	sent / received	
45	BININ_ERR	Instable digital signal	0	number low/high	func-tion
49	INT_ILLEGAL	Illegal interrupt			vector

5. and 6. Safety circuit current generator					
50	POTMET_ERR	Dose regulator not in zero position			
51	ERRORMF_ ERR	MF-error line active			
53	POWER_ERR	Supply voltage sum error		Vsum (ADC)	
54	POTADC_ERR	Dose regulator voltage not 0 V		VPOTmf (ADC)	
55	ERRACT_ERR	MF-error line cannot be deactivated			
56	POTGUARD_ ERR	Dose regulator guard error			
57	NOERRORMF _ERR	MF-error line inactive at poweron			
58	VTEMP_ERR	Temperature much too high		Vtemp (ADC)	
59	MFPOT_ERR	Switch of intensity regulator defective	0	VPOTmf (ADC)	
60	UI_ERR	V/C converter error		Vmf (ADC)	
61	RELPOS_ERR	Safety relay in wrong position			
62	RELSWITCH_ ERR	Safety relay cannot switch		Vmf (ADC)	
63	PAT_ERR	Patient connected		Vmf (ADC)	

64	SHORT_ERR	Short circuit relay error		Vmf (ADC)	
65	RELMAX_ERR	Safety relay doesn't switch at maximum current safety circuit doesn't activate safety relay doesn't switch off	 0 1	 Vmf (ADC)	
66	LIM150_ERR	150% limit circuit error MF-error line active comparator 1 doesn't work comparator 2 doesn't work	 0 1 2		
67	LIMMAX_ERR	Maximum current limit error comparator switches too soon comparator doesn't work	 0 1		

7. Ultrasound generator					
70	HDTYPE_ERR	Unknown head type	L/R	HDtyp* (ADC)	
71	HDTEMP_ERR	Head temperature error	L/R	HDtemp (ADC)	
72	VSNSUS_ERR	Ultrasound supply error Vddus not stable within 1.0s (t/10 s) DAC=0: Vddus> 2.0V DAC=235: Vddus<24.0V Vddus > 18.0V after 0.2s (t/100-1 s)	 ≤100 0 255 ≤200	 Vsnsus (ADC) Vsnsus (ADC) Vsnsus (ADC) Vsnsus (ADC)	
73	US_ERR	General ultrasound error DAC=0: ERRORus already active TST4=1: ERRORus active ERRORus active at Vddus1 ERRORus not active at Vddus2 TST4=0: ERRORus active	 1 2 3 4 5	 port US port US port US port US port US	
74	VUSI_ERR	Vusi > 0 V at duty-cycle 1:0	0		
79	USPOT_ERR	Switch of ultrasound intensity regulator is defective	0	VPOTus (ADC)	

8. Laser generator

80	PBTYPE_ERR	Probe type unknown	L/R	PBtyp* (ADC)	
81	PBACT_ERR	PbAct active during test	L/R		
82	LSEYE_ERR	Voltage laser test cell error		LASeye (ADC)	
83	LS_ERR	General laser error			
89	LSPOT_ERR	Switch of laser dosage regulator defective	0	VPOTlas (ADC)	

CHAPTER 6 CIRCUIT DIAGRAMS

Overview of the circuit diagrams:

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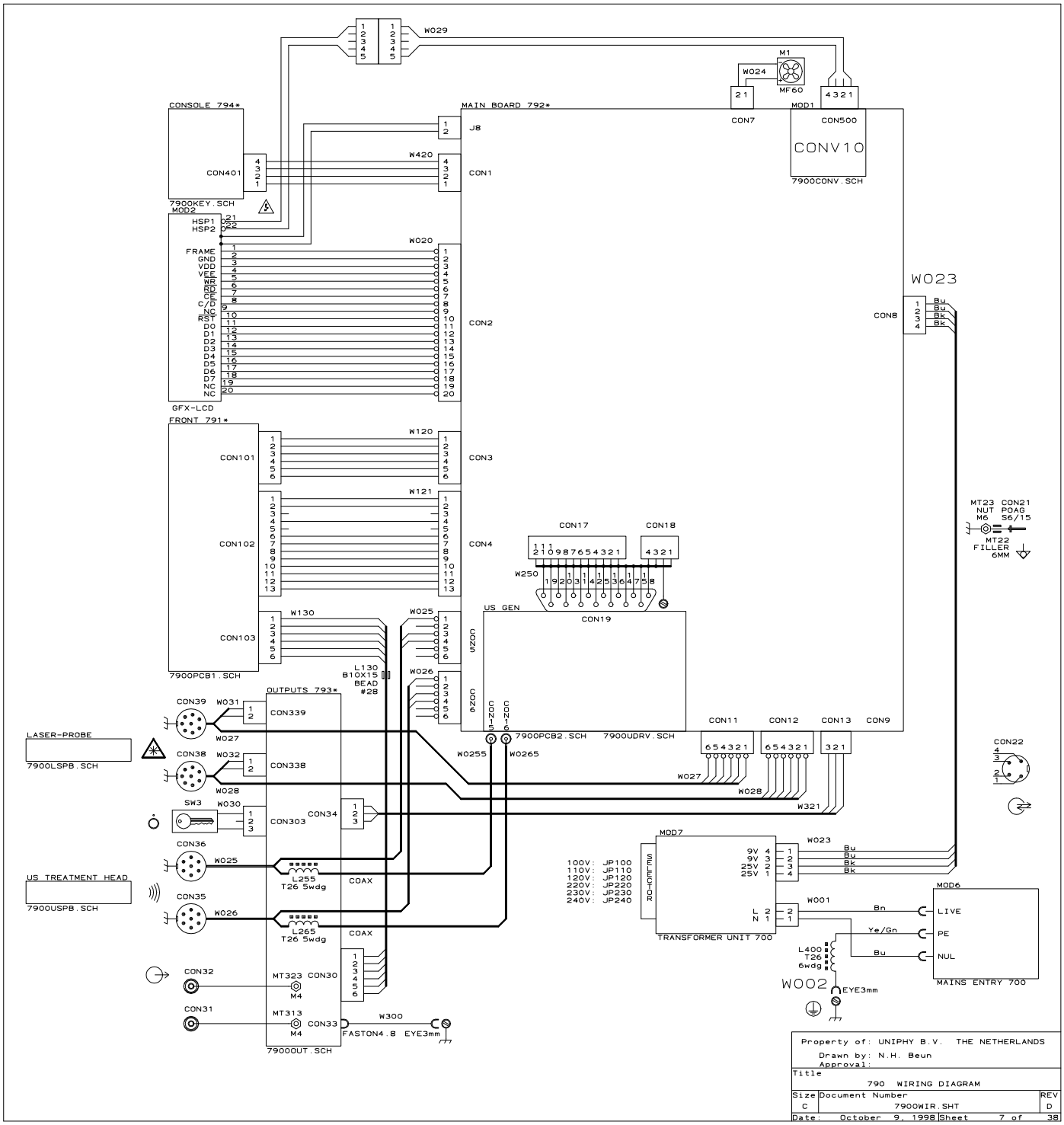
Sheet 12 Waveform synthesis
Sheet 13 V/I Converter
Sheet 14 Safety
Sheet 15 Controls & rectifier
Sheet 16 Outputs
Sheet 17 Console
Sheet 18 US control
Sheet 20 Probe driver
Sheet 21 Mains supply
Sheet 21b RFI-filter mains inlet
Sheet 22 Backlight converter
Sheet 23 US treatment head
Sheet 24 Laser probe
Sheet 26 Connector definition
Sheet 27 Semiconductor pin-outs
Sheet 28 Layout front PCB
Sheet 29 Layout main PCB
Sheet 31 Layout probes
Sheet 32 Component index
Sheet 33 Label cross reference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VEE
WR
RD
CS
C/D
NC
RST
D0
D1
D2
D3
D4
D5
D6
D7
NC
NC
CON2
GFX-LCD
W023
CON8
Bu
Bu
Bk
Bk
FRONT 791*
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CON102
CON103
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W121
W130
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CON4
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CON18
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US GEN
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7900UDRV.SCH
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NUT POAG
M6 S6/15
MT22
FILLER
6MM
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CON12
CON13
CON9
W027
W028
W321
W0255
W0265
CON22
OUTPUTS 793*
CON39
W031
CON339
LASER-PROBE
7900LSPB.SCH
CON38
W032
CON338
SW3
W030
CON303
CON34
CON36
CON35
L255
T26 5wdg
L265
T26 5wdg
COAX
US TREATMENT HEAD
7900USPB.SCH
CON32
MT323 CON30
M4
CON31
MT313
CON33
W300
FASTON4.8 EYE3mm
79000UT.SCH
MOD7
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110V: JP110
120V: JP120
220V: JP220
230V: JP230
240V: JP240
SWITCH-MODE
9V
9V
25V
25V
L
N
TRANSFORMER UNIT 700
W001
Bn
Ye/Gn
Bu
L400
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6wdg
W002
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MOD6
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Size C
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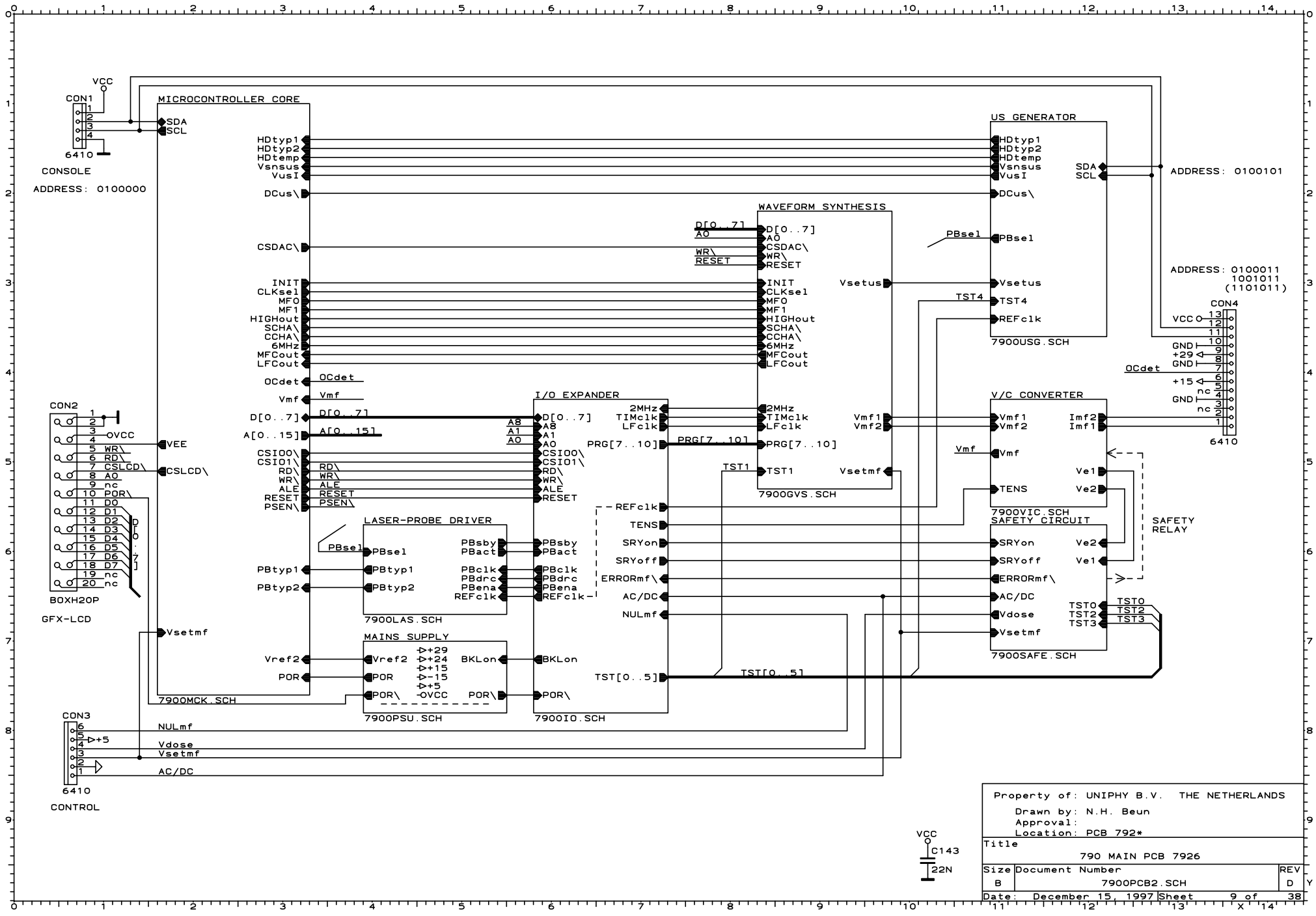
Sheet 7 of 38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A0
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SRYon
SRYoff
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NULmf
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PBact
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PBtyp2
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PBena
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MAINS SUPPLY
Vref2
POR
BKLon
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+24
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-OVCC
POR\
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SDA
SCL
7900USG.SCH
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(1101011)
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GND
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+15
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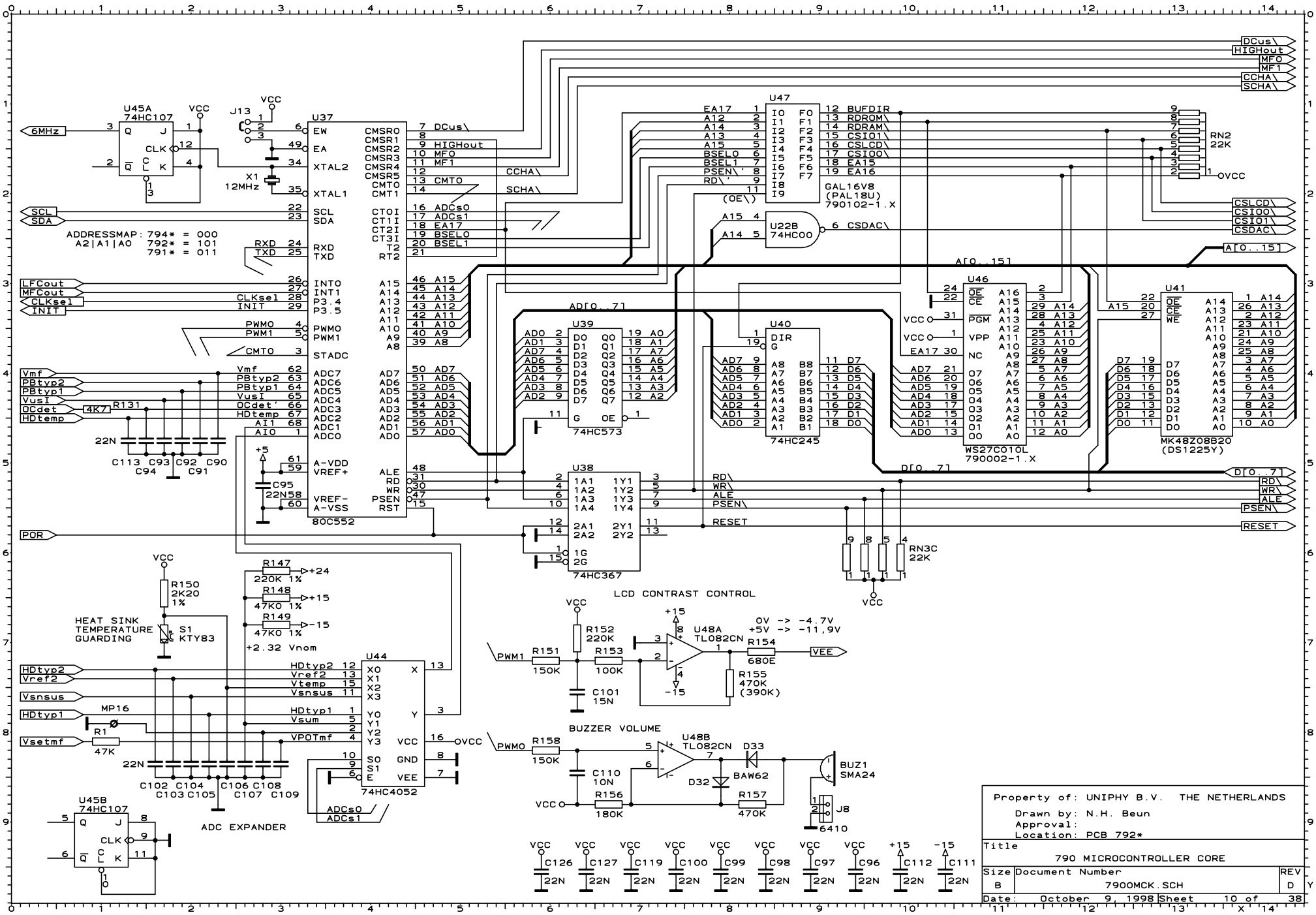
Sheet 9 of 38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PWM1
CMT0
Vmf
PBtyp2
PBtyp1
VusI
OCdet
HDtemp
R131
4K7
22N
C113 C93 C92 C90
C94 C91
C95
22N
+5
AI1
AIO
A-VDD
VREF+
VREF-
A-VSS
CMSR0
CMSR1
CMSR2
CMSR3
CMSR4
CMSR5
CMTO
CMT1
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CT3I
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ADC5
ADC4
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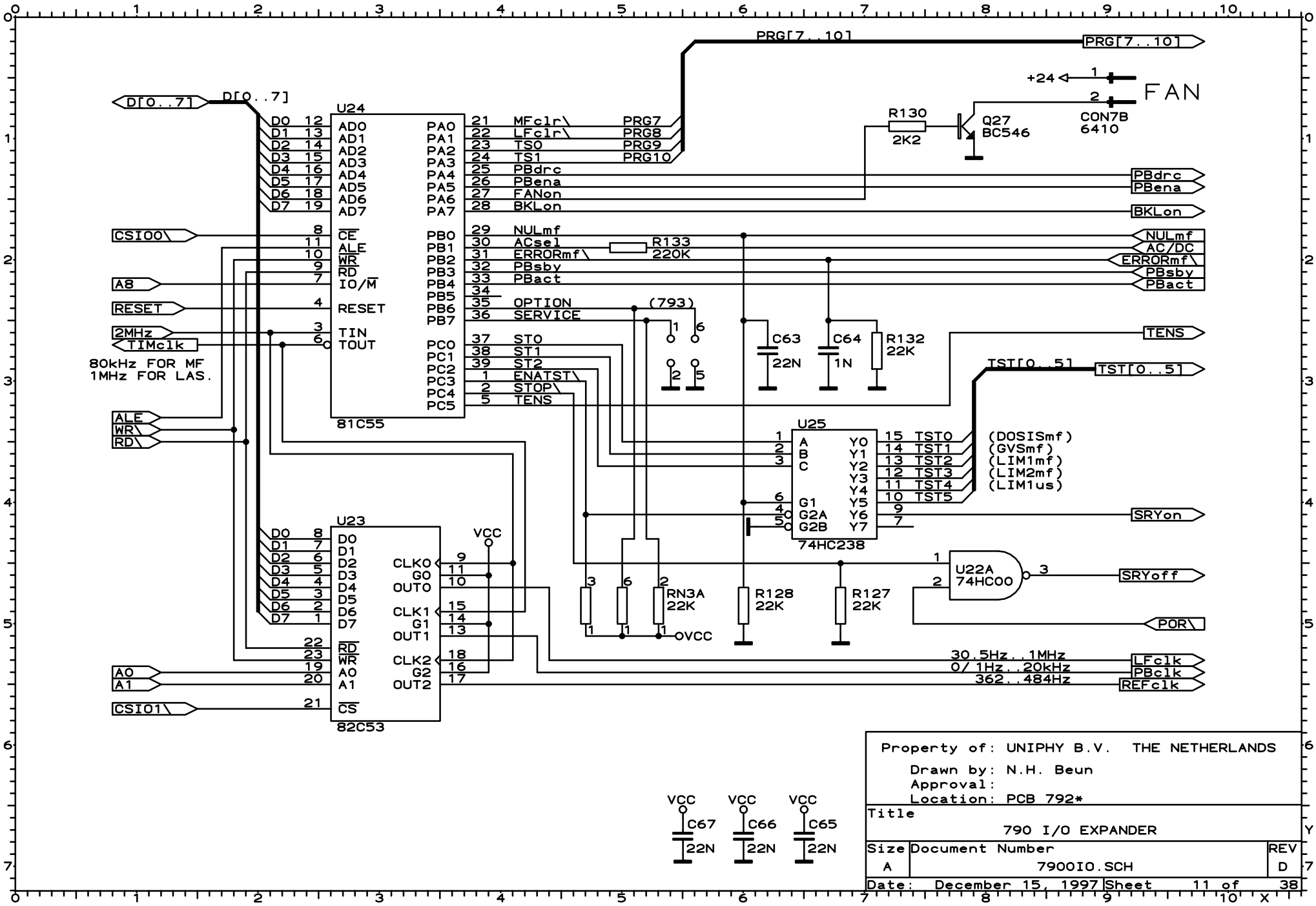
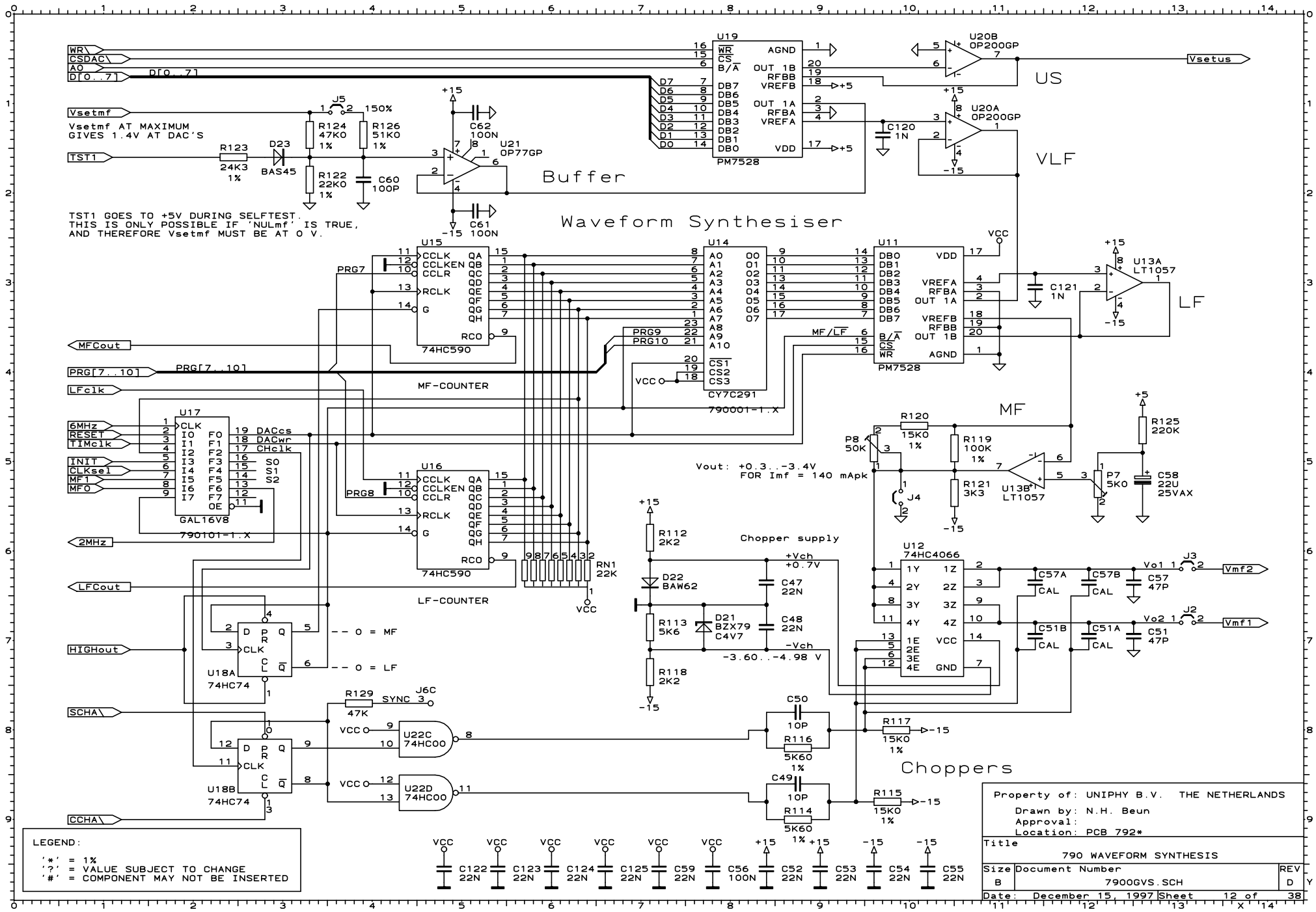
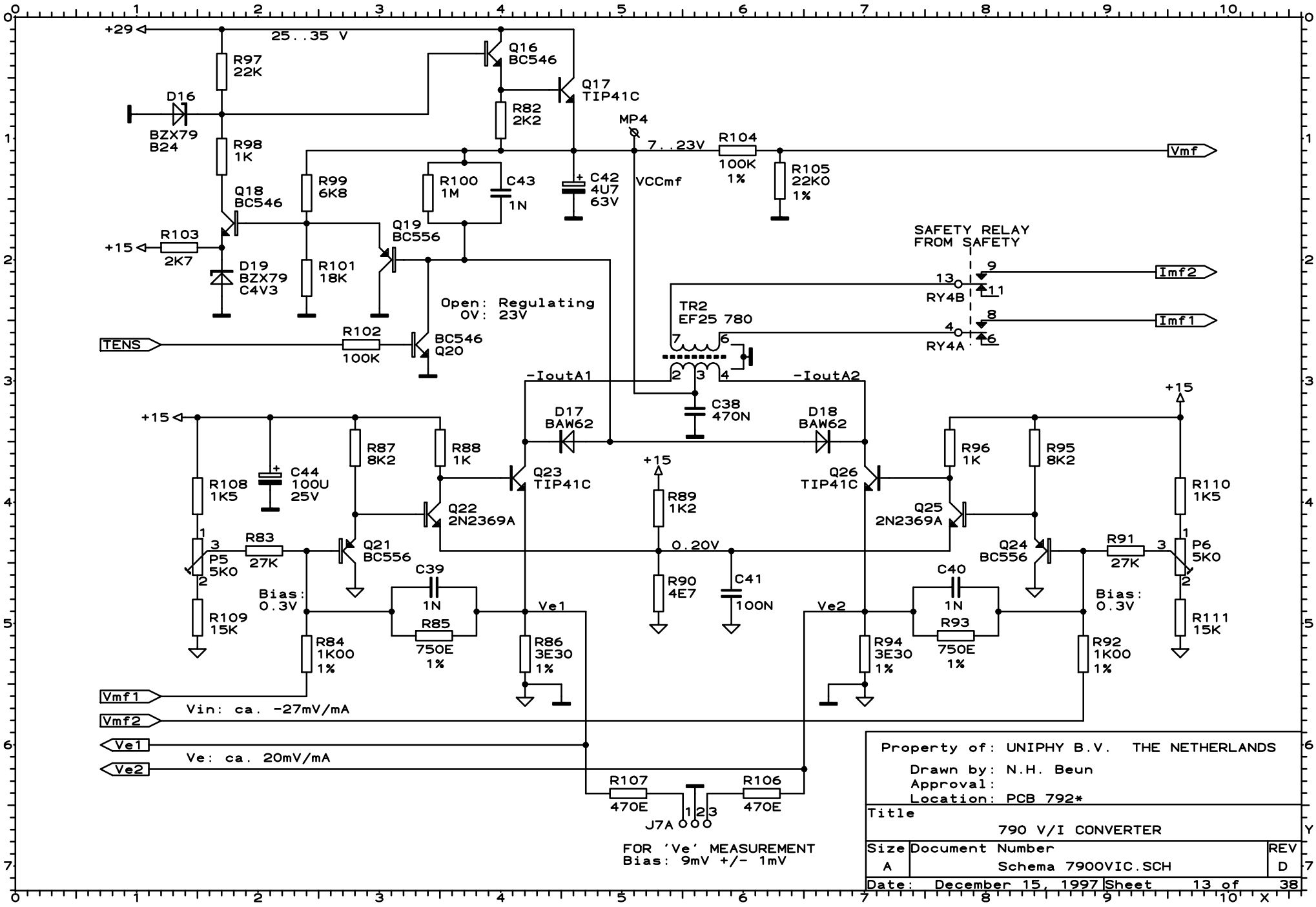
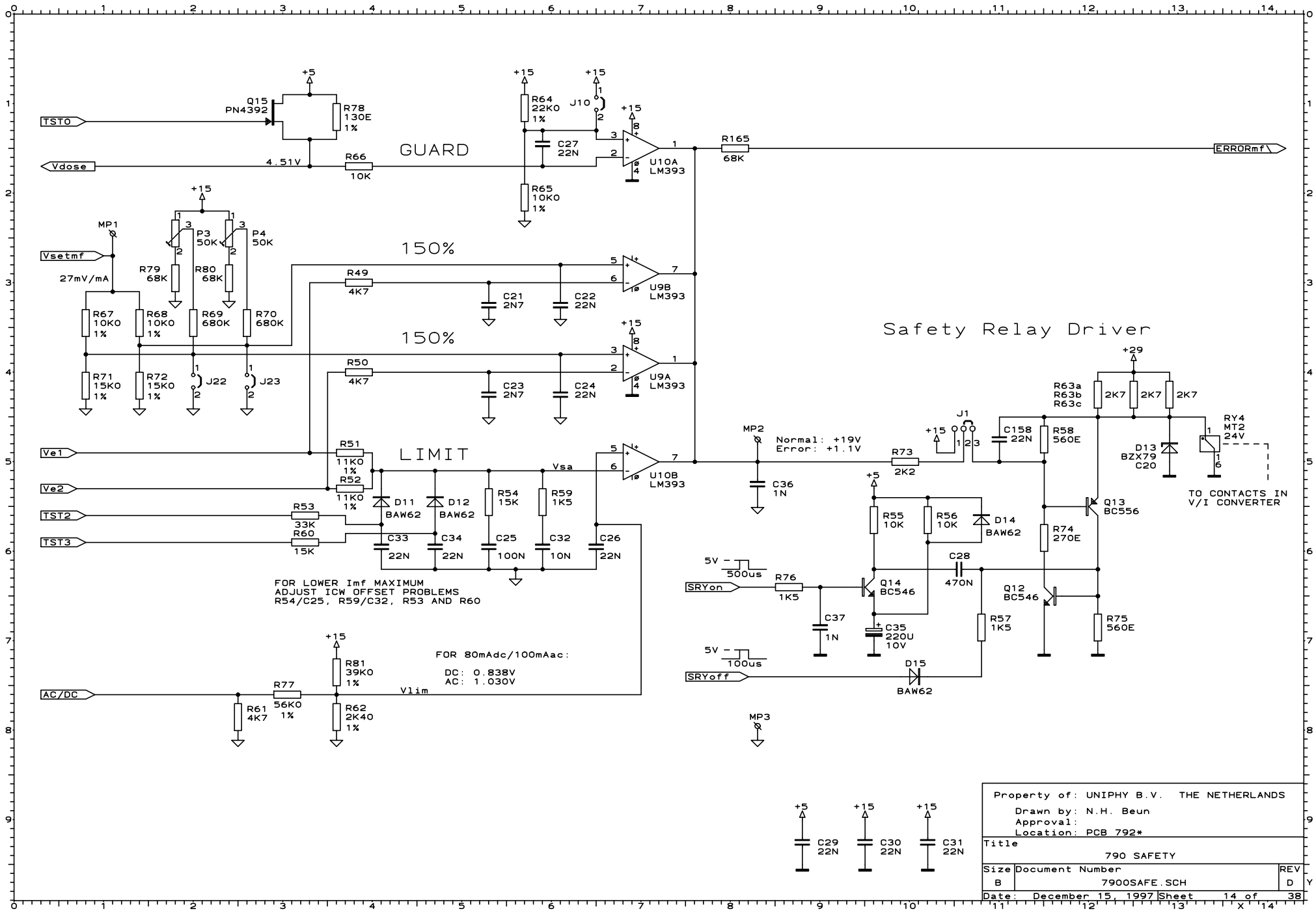
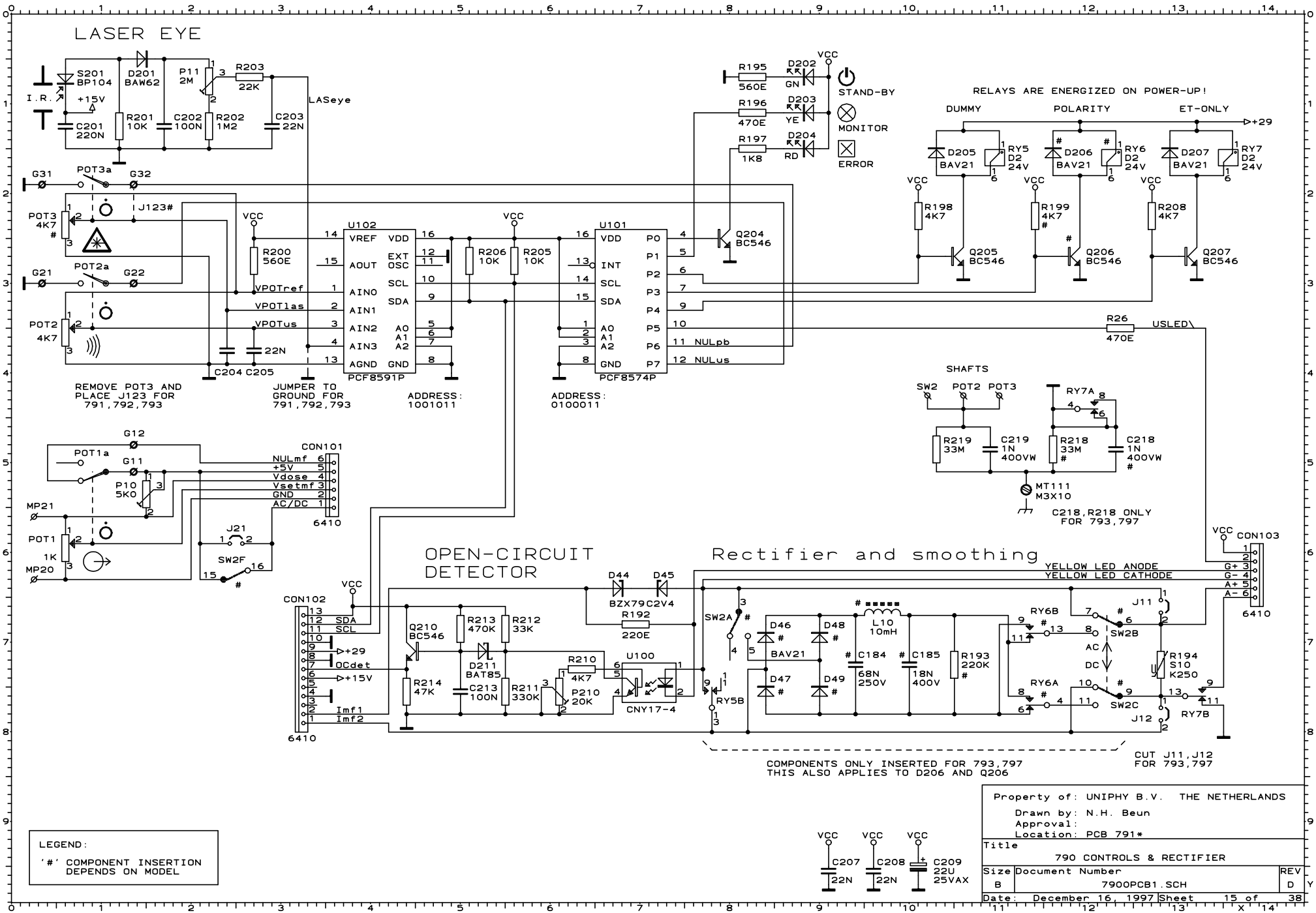
U38
74HC367
POR
RN3C
22K
R147
220K 1%
+24
R148
47KO 1%
+15
R149
47KO 1%
-15
+2.32 Vnom
R150
2K20
1%
HEAT SINK
TEMPERATURE
GUARDING
S1
KTY83
U44
74HC4052
HDtyp2
Vref2
Vsnsus
HDtyp1
Vsetmf
MP16
R1
47K
Vtemp
Vsum
VPOTmf
22N
C102 C104 C106 C108
C103 C105 C107 C109
ADC EXPANDER
U45B
74HC107
LCD CONTRAST CONTROL
R152
220K
R153
100K
R151
150K
PWM1
C101
15N
U48A
TL082CN
R154
680E
VEE
R155
470K
(390K)
0V -> -4.7V
+5V -> -11,9V
BUZZER VOLUME
PWMO
R158
150K
C110
10N
U48B
TL082CN
D33
D32
BAW62
R156
180K
R157
470K
BUZ1
SMA24
J8
6410
C126 C127 C119 C100 C99 C98 C97 C96 C112 C111
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB 792*
Title
790 MICROCONTROLLER CORE
Size B
Document Number 7900MCK.SCH
REV D
Date: October 9, 1998
Sheet 10 of 38

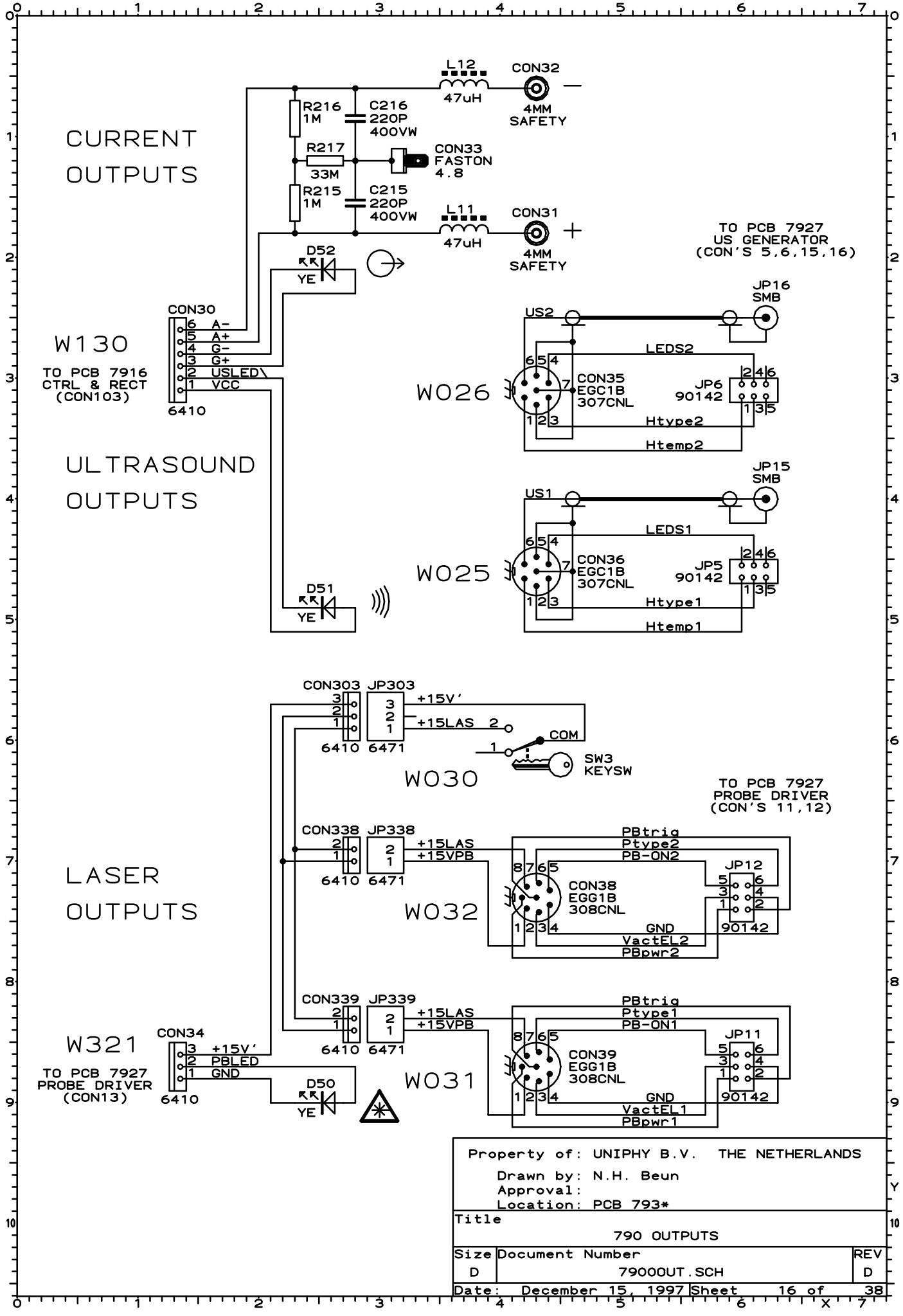

PRG[7..10]
PRG[7..10]
+24
1
2
FAN
CON7B
6410
R130
2K2
Q27
BC546
D[0..7]
D[0..7]
U24
D0 12
D1 13
D2 14
D3 15
D4 16
D5 17
D6 18
D7 19
AD0
AD1
AD2
AD3
AD4
AD5
AD6
AD7
PA0 21 MFclr\ PRG7
PA1 22 LFclr\ PRG8
PA2 23 TS0 PRG9
PA3 24 TS1 PRG10
PA4 25 PBdrc
PA5 26 PBena
PA6 27 FANon
PA7 28 BKLon
PBdrc
PBena
BKLon
CSIO0\
8 CE
11 ALE
10 WR
9 RD
7 IO/M
4 RESET
3 TIN
6 TOUT
PB0 29 NULmf
PB1 30 ACsel
PB2 31 ERRORmf\
PB3 32 PBsby
PB4 33 PBact
PB5 34
PB6 35 OPTION
PB7 36 SERVICE
PC0 37 ST0
PC1 38 ST1
PC2 39 ST2
PC3 1 ENATST\
PC4 2 STOP\
PC5 5 TENS
81C55
R133
220K
NULmf
AC/DC
ERRORmf\
PBsby
PBact
A8
RESET
2MHz
TIMclk
80kHz FOR MF
1MHz FOR LAS.
(793)
1
6
2
5
C63
22N
C64
1N
R132
22K
TENS
TST[0..5]
TST[0..5]
ALE
WR\
RD\
U25
1 A
2 B
3 C
6 G1
4 G2A\
5 G2B\
Y0 15 TST0
Y1 14 TST1
Y2 13 TST2
Y3 12 TST3
Y4 11 TST4
Y5 10 TST5
Y6 9
Y7 7
74HC238
(DOSISmf)
(GVSmf)
(LIM1mf)
(LIM2mf)
(LIM1us)
SRYon
U23
D0 8
D1 7
D2 6
D3 5
D4 4
D5 3
D6 2
D7 1
D0
D1
D2
D3
D4
D5
D6
D7
CLK0 9
G0 11
OUT0 10
CLK1 15
G1 14
OUT1 13
CLK2 18
G2 16
OUT2 17
VCC
22 RD\
23 WR\
19 A0
20 A1
21 CS\
82C53
RN3A
22K
R128
22K
R127
22K
VCC
U22A
74HC00
1
2
3
SRYoff
POR\
30.5Hz..1MHz
0/1Hz..20kHz
362..484Hz
LFclk
PBclk
REFclk
A0
A1
CSIO1\
VCC
VCC
VCC
C67
22N
C66
22N
C65
22N
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB 792*
Title
790 I/O EXPANDER
Size
A
Document Number
7900IO.SCH
REV
D
Date: December 15, 1997
Sheet 11 of 38


WR\
CSDAC\
A0
D[0..7]
D[0..7]
Vsetmf
Vsetmf AT MAXIMUM
GIVES 1.4V AT DAC'S
TST1
R123
24K3
1%
D23
BAS45
J5
150%
R124
47K0
1%
R126
51K0
1%
R122
22K0
1%
C60
100P
+15
C62
100N
U21
OP77GP
-15
C61
100N
Buffer
TST1 GOES TO +5V DURING SELFTEST.
THIS IS ONLY POSSIBLE IF 'NULmf' IS TRUE,
AND THEREFORE Vsetmf MUST BE AT 0 V.
U19
PM7528
AGND
OUT 1B
RFBB
VREFB
OUT 1A
RFBA
VREFA
VDD
U20B
OP200GP
US
Vsetus
U20A
OP200GP
VLF
C120
1N
Waveform Synthesiser
U15
74HC590
U14
CY7C291
790001-1.X
U11
PM7528
U13A
LT1057
LF
C121
1N
PRG7
PRG9
PRG10
MF/LF
MFCout
PRG[7..10]
MF-COUNTER
LFclk
U17
GAL16V8
790101-1.X
6MHz
RESET
TIMclk
INIT
CLKsel
MF1
MF0
DACcs
DACwr
CHclk
S0
S1
S2
2MHz
U16
74HC590
PRG8
LFCout
LF-COUNTER
RN1
22K
MF
R120
15K0
1%
P8
50K
R119
100K
1%
R121
3K3
J4
U13B
LT1057
P7
5K0
R125
220K
C58
22U
25VAX
Vout: +0.3..-3.4V
FOR Imf = 140 mApk
Chopper supply
R112
2K2
D22
BAW62
R113
5K6
D21
BZX79
C4V7
R118
2K2
+Vch
+0.7V
C47
22N
C48
22N
-Vch
-3.60..-4.98 V
U12
74HC4066
C57A
C57B
C57
47P
C51B
C51A
C51
47P
Vo1
Vo2
J3
J2
Vmf2
Vmf1
HIGHout
U18A
74HC74
-- 0 = MF
-- 0 = LF
SCHA\
CCHA\
R129
47K
SYNC
J6C
U22C
74HC00
U22D
74HC00
U18B
74HC74
C50
10P
R116
5K60
1%
C49
10P
R114
5K60
1%
R117
15K0
1%
R115
15K0
1%
Choppers
LEGEND:
'*' = 1%
'?' = VALUE SUBJECT TO CHANGE
'#' = COMPONENT MAY NOT BE INSERTED
C122 22N
C123 22N
C124 22N
C125 22N
C59 22N
C56 100N
C52 22N
C53 22N
C54 22N
C55 22N
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB 792*
Title
790 WAVEFORM SYNTHESIS
Size B
Document Number 7900GVS.SCH
REV D
Date: December 15, 1997
Sheet 12 of 38

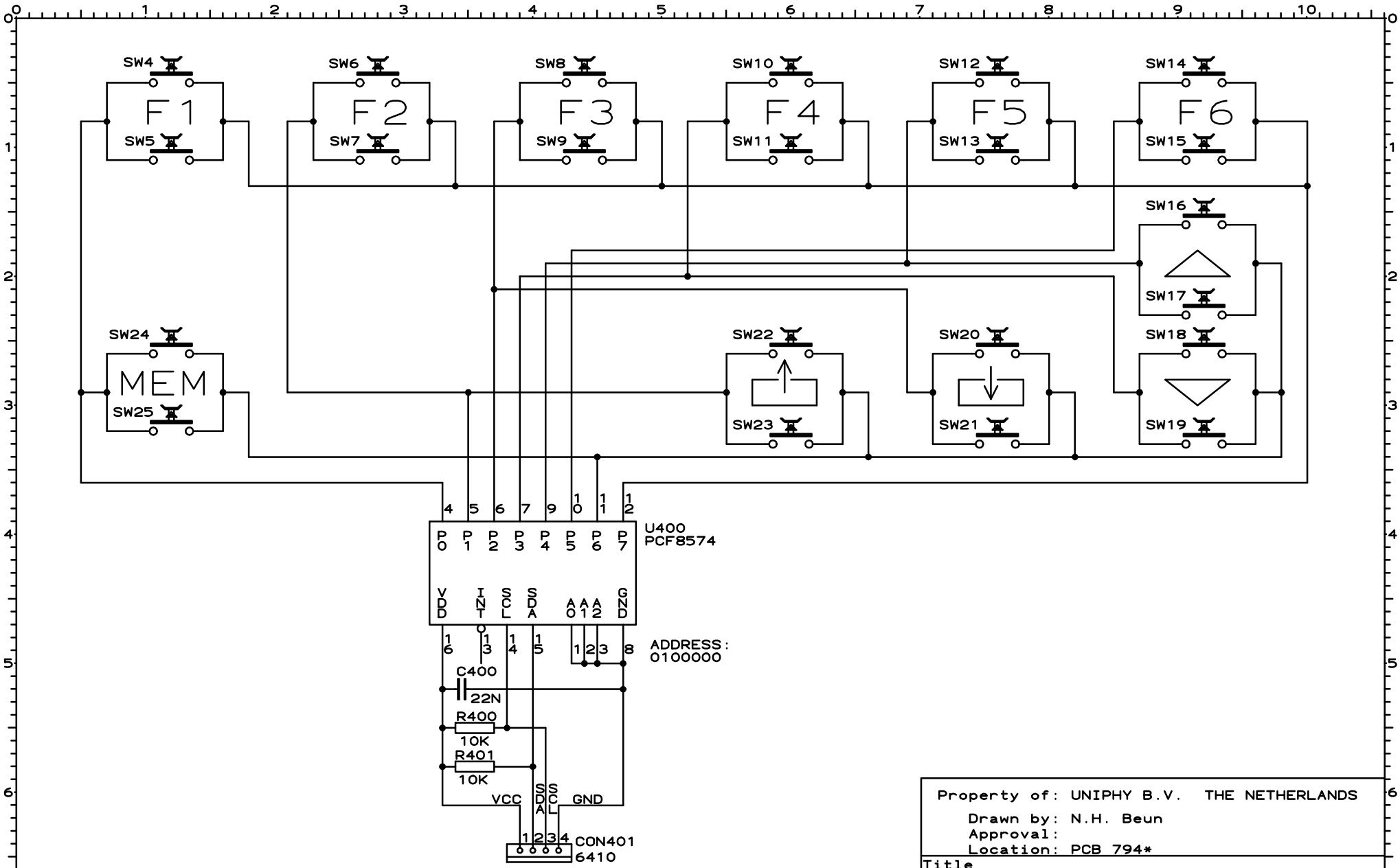

+29
25..35 V
R97
22K
D16
BZX79
B24
R98
1K
Q16
BC546
Q17
TIP41C
R82
2K2
MP4
7..23V
R104
100K
1%
R105
22K0
1%
Vmf
R99
6K8
R100
1M
C43
1N
C42
4U7
63V
VCCmf
Q18
BC546
Q19
BC556
R103
2K7
+15
D19
BZX79
C4V3
R101
18K
Open: Regulating
0V: 23V
SAFETY RELAY
FROM SAFETY
13
RY4B
9
11
Imf2
TR2
EF25 780
8
6
4
RY4A
Imf1
TENS
R102
100K
BC546
Q20
-IoutA1
-IoutA2
C38
470N
D17
BAW62
D18
BAW62
+15
R87
8K2
R88
1K
R108
1K5
C44
100U
25V
Q23
TIP41C
Q22
2N2369A
+15
R89
1K2
0.20V
R90
4E7
C41
100N
Q26
TIP41C
Q25
2N2369A
R96
1K
R95
8K2
R110
1K5
P5
5K0
R83
27K
Q21
BC556
Bias:
0.3V
C39
1N
R85
750E
1%
Ve1
R84
1K00
1%
R86
3E30
1%
Ve2
C40
1N
R93
750E
1%
R94
3E30
1%
Q24
BC556
R91
27K
P6
5K0
Bias:
0.3V
R92
1K00
1%
R109
15K
R111
15K
Vmf1
Vin: ca. -27mV/mA
Vmf2
Ve1
Ve: ca. 20mV/mA
Ve2
R107
470E
R106
470E
J7A
1 2 3
FOR 'Ve' MEASUREMENT
Bias: 9mV +/- 1mV
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB 792*
Title
790 V/I CONVERTER
Size
A
Document Number
Schema 7900VIC.SCH
REV
D
Date: December 15, 1997
Sheet 13 of 38


GUARD
150%
150%
LIMIT
Safety Relay Driver
Q15 PN4392
R78 130E 1%
R64 22K0 1%
J10
C27 22N
R65 10K0 1%
U10A LM393
R165 68K
ERRORmf
TST0
Vdose
4.51V
R66 10K
MP1
Vsetmf
27mV/mA
P3 50K
P4 50K
R79 68K
R80 68K
R67 10K0 1%
R68 10K0 1%
R69 680K
R70 680K
R71 15K0 1%
R72 15K0 1%
J22
J23
R49 4K7
C21 2N7
C22 22N
U9B LM393
R50 4K7
C23 2N7
C24 22N
U9A LM393
Ve1
Ve2
TST2
TST3
R51 11K0 1%
R52 11K0 1%
R53 33K
R60 15K
D11 BAW62
D12 BAW62
R54 15K
R59 1K5
C33 22N
C34 22N
C25 100N
C32 10N
C26 22N
Vsa
U10B LM393
FOR LOWER Imf MAXIMUM
ADJUST ICW OFFSET PROBLEMS
R54/C25, R59/C32, R53 AND R60
AC/DC
R77 56K0 1%
R81 39K0 1%
R61 4K7
R62 2K40 1%
Vlim
FOR 80mAdc/100mAac:
DC: 0.838V
AC: 1.030V
MP2
Normal: +19V
Error: +1.1V
R73 2K2
C36 1N
J1
C158 22N
R58 560E
R63a R63b R63c 2K7 2K7 2K7
RY4 MT2 24V
D13 BZX79 C20
TO CONTACTS IN V/I CONVERTER
R55 10K
R56 10K
D14 BAW62
Q13 BC556
R74 270E
C28 470N
SRYon
R76 1K5
Q14 BC546
Q12 BC546
C37 1N
C35 220U 10V
R57 1K5
R75 560E
SRYoff
D15 BAW62
MP3
C29 22N
C30 22N
C31 22N
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB 792*
Title
790 SAFETY
Size B
Document Number 7900SAFE.SCH
REV D
Date: December 15, 1997
Sheet 14 of 38

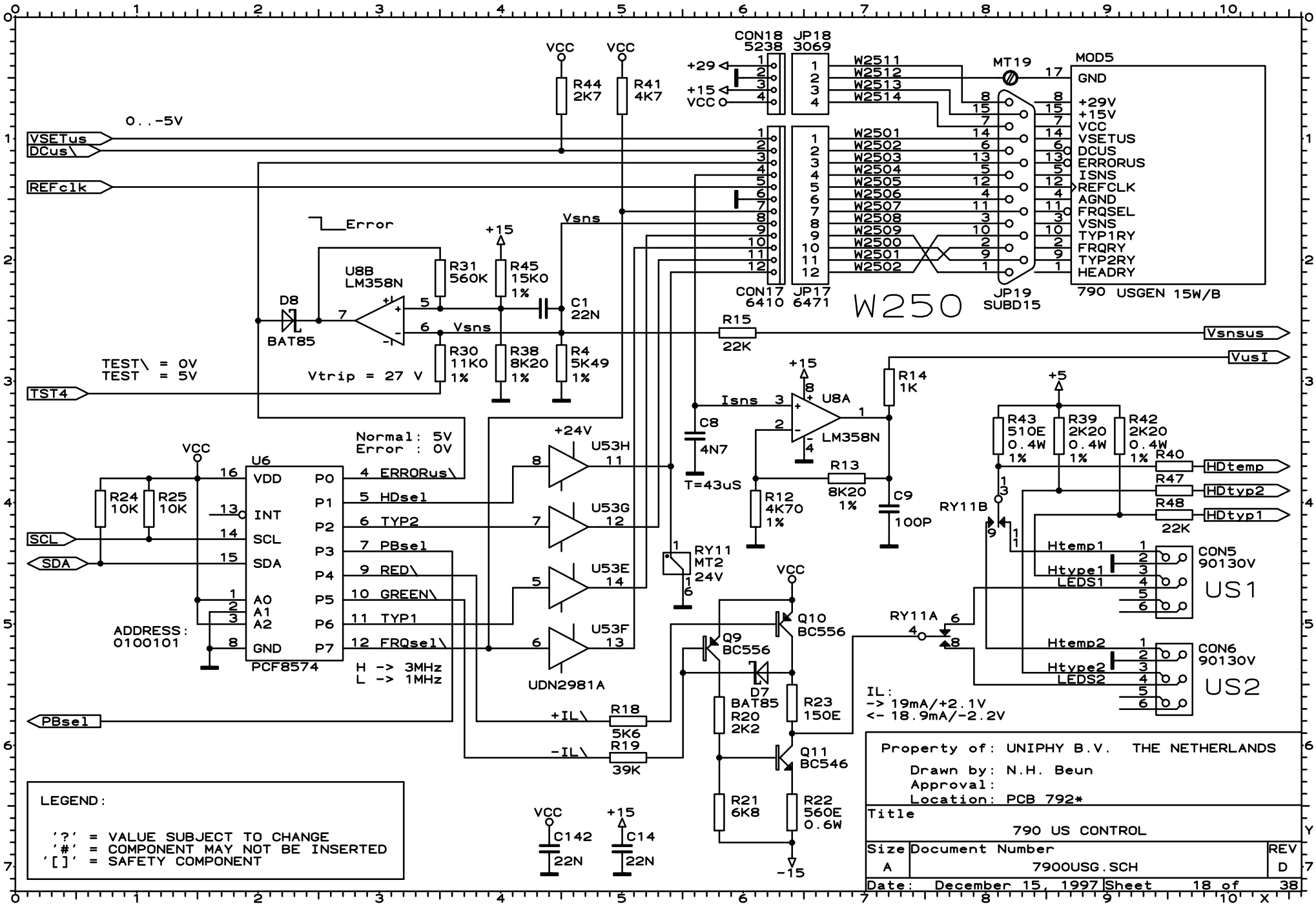

LASER EYE
S201 BP104
I.R.
D201 BAW62
+15V
P11 2M
R203 22K
LASeye
C201 220N
R201 10K
C202 100N
R202 1M2
C203 22N
R195 560E
R196 470E
R197 1K8
D202 GN
D203 YE
D204 RD
VCC
STAND-BY
MONITOR
ERROR
RELAYS ARE ENERGIZED ON POWER-UP!
DUMMY
POLARITY
ET-ONLY
+29
D205 BAV21
D206 BAV21
D207 BAV21
RY5 D2 24V
RY6 D2 24V
RY7 D2 24V
R198 4K7
R199 4K7 #
R208 4K7
Q205 BC546
Q206 BC546
Q207 BC546
G31
POT3a
G32
POT3 4K7 #
J123#
G21
POT2a
G22
POT2 4K7
R200 560E
VPOTref
VPOTlas
VPOTus
22N
C204 C205
U102
VREF VDD
AOUT EXT OSC
AIN0 SCL
AIN1 SDA
AIN2 A0
AIN3 A1 A2
AGND GND
PCF8591P
R206 10K
R205 10K
U101
VDD P0
INT P1
SCL P2
SDA P3
P4
A0 P5
A1
A2 P6
GND P7
PCF8574P
Q204 BC546
R26 470E
USLED\
NULpb
NULus
REMOVE POT3 AND PLACE J123 FOR 791,792,793
JUMPER TO GROUND FOR 791,792,793
ADDRESS: 1001011
ADDRESS: 0100011
SHAFTS
SW2 POT2 POT3
RY7A
R219 33M
C219 1N 400VW
R218 33M #
C218 1N 400VW #
MT111 M3X10
C218,R218 ONLY FOR 793,797
G12
POT1a
G11
P10 5K0
MP21
POT1 1K
MP20
J21
SW2F
CON101
NULmf
+5V
Vdose
Vsetmf
GND
AC/DC
6410
OPEN-CIRCUIT DETECTOR
Rectifier and smoothing
CON102
SDA
SCL
+29
OCdet
+15V
Imf1
Imf2
6410
Q210 BC546
R213 470K
R212 33K
D211 BAT85
R214 47K
C213 100N
R211 330K
R210 4K7
P210 20K
U100
CNY17-4
D44 D45
BZX79C2V4
R192 220E
SW2A
RY5B
D46 D48
BAV21
D47 D49
L10 10mH
C184 68N 250V
C185 18N 400V
R193 220K #
RY6B
RY6A
SW2B
SW2C
AC
DC
R194 S10 K250
J11
J12
RY7B
CON103
YELLOW LED ANODE
YELLOW LED CATHODE
G+
G-
A+
A-
6410
CUT J11,J12 FOR 793,797
COMPONENTS ONLY INSERTED FOR 793,797
THIS ALSO APPLIES TO D206 AND Q206
C207 22N
C208 22N
C209 22U 25VAX
LEGEND:
'#' COMPONENT INSERTION DEPENDS ON MODEL
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB 791*
Title
790 CONTROLS & RECTIFIER
Size B
Document Number 7900PCB1.SCH
REV D
Date: December 16, 1997
Sheet 15 of 38

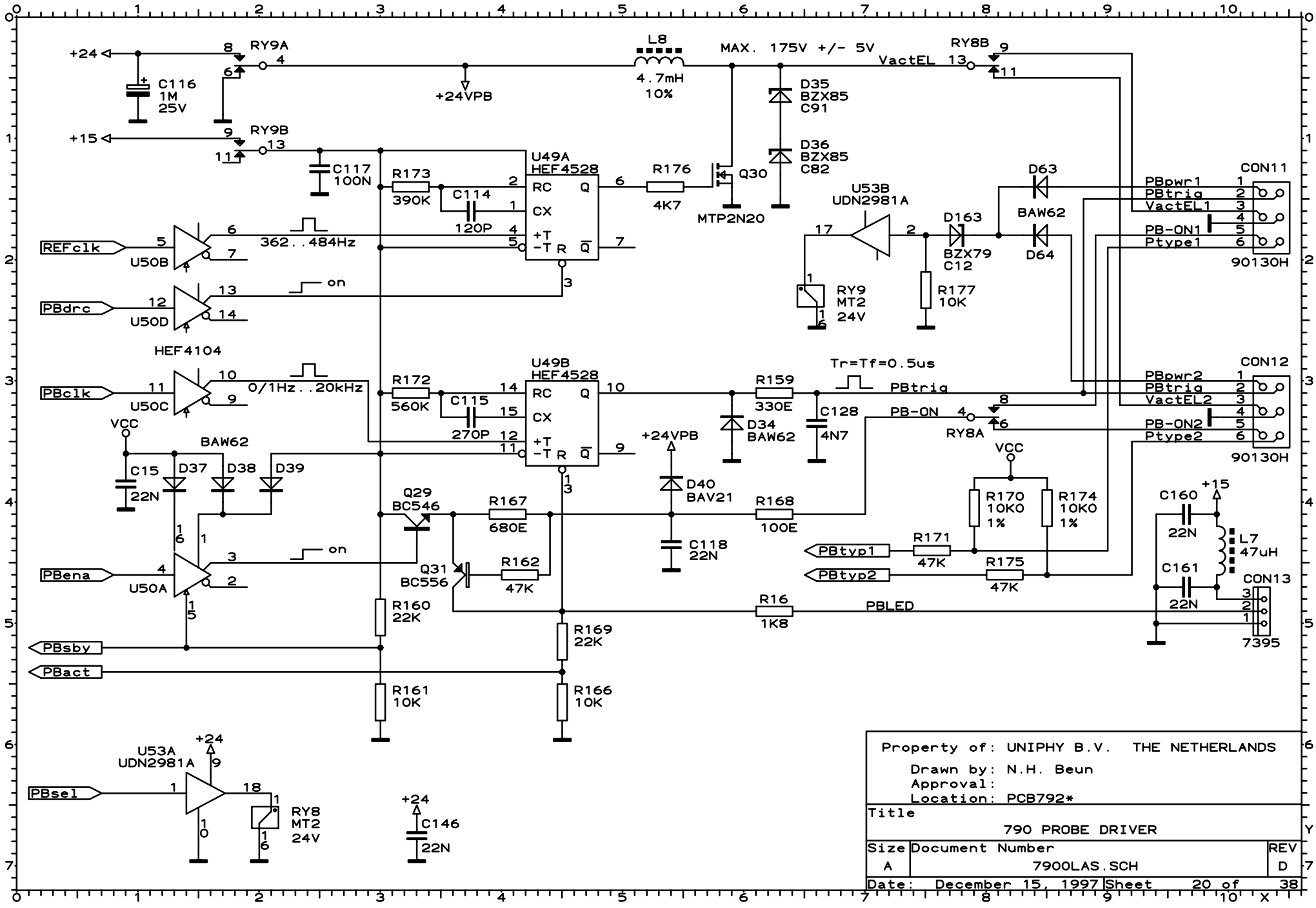


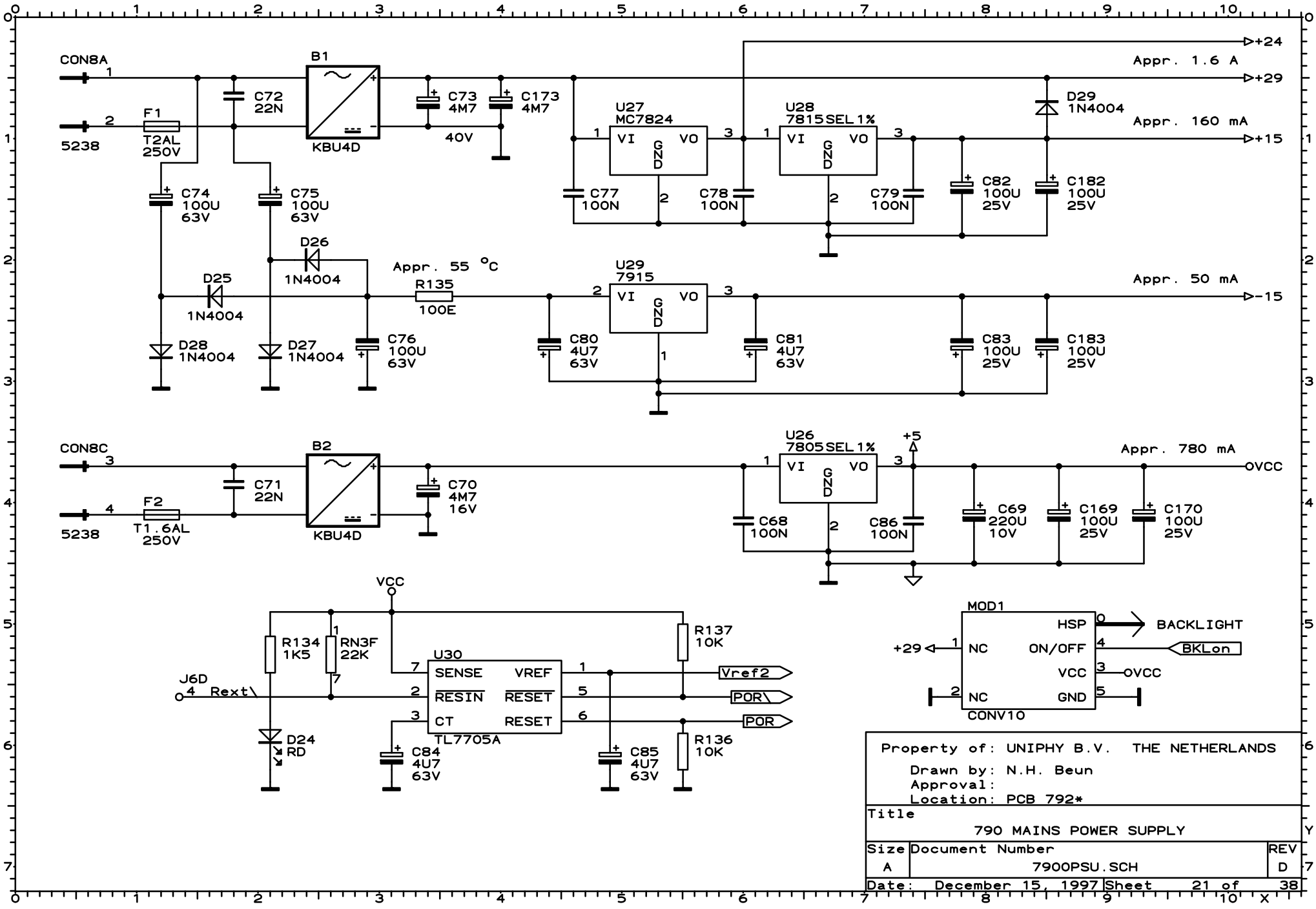
Property of: UNIPHY B.V. THE NETHERLANDS	
Drawn by: N.H. Beun	
Approval:	
Location: PCB 793*	
Title: 790 OUTPUTS	
Size: D	Document Number: 7900OUT.SCH — REV: D
Date: December 15, 1997	Sheet 16 of 38



Property of:	UNIPHY B.V. THE NETHERLANDS
Drawn by:	N.H. Beun
Approval:	
Location:	PCB 794*
Title	790 CONSOLE
Size	A
Document Number	Schema 7900KEY.SCH
REV	D
Date:	December 16, 1997
Sheet	17 of 38


CON18 5238
JP18 3069
MT19
MOD5
W250
CON17 6410
JP17 6471
JP19 SUBD15
790 USGEN 15W/B
GND
+29V
+15V
VCC
VSETUS
DCUS
ERRORUS
ISNS
REFCLK
AGND
FRQSEL
VSNS
TYP1RY
FRQRY
TYP2RY
HEADRY
0..-5V
VSETus
DCus\
REFclk
Error
Vsns
U8B LM358N
D8 BAT85
R31 560K
R45 15K0 1%
C1 22N
R30 11K0 1%
R38 8K20 1%
R4 5K49 1%
Vtrip = 27 V
R15 22K
Vsnsus
VusI
TEST\ = 0V
TEST = 5V
TST4
U8A LM358N
Isns
R14 1K
C8 4N7
T=43uS
R12 4K70 1%
R13 8K20 1%
C9 100P
R43 510E 0.4W 1%
R39 2K20 0.4W 1%
R42 2K20 0.4W 1%
R40
R47
R48 22K
HDtemp
HDtyp2
HDtyp1
RY11B
Htemp1
Htype1
LEDS1
CON5 90130V
US1
Htemp2
Htype2
LEDS2
CON6 90130V
US2
Normal: 5V
Error : 0V
U6
PCF8574
ERRORus\
HDsel
TYP2
PBsel
RED\
GREEN\
TYP1
FRQsel\
ADDRESS: 0100101
H -> 3MHz
L -> 1MHz
R24 10K
R25 10K
SCL
SDA
U53H 11
U53G 12
U53E 14
U53F 13
UDN2981A
RY11 MT2 24V
RY11A
Q10 BC556
Q9 BC556
D7 BAT85
R20 2K2
R23 150E
Q11 BC546
R21 6K8
R22 560E 0.6W
+IL\
-IL\
R18 5K6
R19 39K
PBsel
IL:
-> 19mA/+2.1V
<- 18.9mA/-2.2V
LEGEND:
'?' = VALUE SUBJECT TO CHANGE
'#' = COMPONENT MAY NOT BE INSERTED
'[]' = SAFETY COMPONENT
C142 22N
C14 22N
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB 792*
Title
790 US CONTROL
Size A
Document Number 7900USG.SCH
REV D
Date: December 15, 1997
Sheet 18 of 38


+24
C116
1M
25V
RY9A
+24VPB
L8
4.7mH
10%
MAX. 175V +/- 5V
VactEL
RY8B
D35
BZX85
C91
D36
BZX85
C82
+15
RY9B
C117
100N
R173
390K
C114
120P
U49A
HEF4528
RC
CX
+T
-T
R
Q
R176
4K7
Q30
MTP2N20
U53B
UDN2981A
D63
BAW62
D64
D163
BZX79
C12
R177
10K
RY9
MT2
24V
CON11
PBpwr1
PBtrig
VactEL1
PB-ON1
Ptype1
90130H
REFclk
U50B
362..484Hz
PBdrc
U50D
on
HEF4104
PBclk
U50C
0/1Hz..20kHz
U49B
HEF4528
R172
560K
C115
270P
Tr=Tf=0.5us
PBtrig
R159
330E
C128
4N7
D34
BAW62
PB-ON
RY8A
CON12
PBpwr2
PBtrig
VactEL2
PB-ON2
Ptype2
90130H
VCC
C15
22N
BAW62
D37
D38
D39
+24VPB
D40
BAV21
C118
22N
R168
100E
R167
680E
Q29
BC546
Q31
BC556
R162
47K
PBena
U50A
PBsby
PBact
R160
22K
R161
10K
R169
22K
R166
10K
R16
1K8
PBLED
R170
10K0
1%
R174
10K0
1%
R171
47K
R175
47K
PBtyp1
PBtyp2
C160
22N
C161
22N
L7
47uH
CON13
7395
U53A
UDN2981A
PBsel
RY8
MT2
24V
C146
22N
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB792*
Title
790 PROBE DRIVER
Size
A
Document Number
7900LAS.SCH
REV
D
Date: December 15, 1997
Sheet 20 of 38



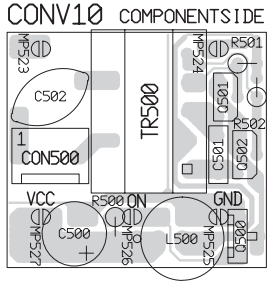
Property of: UNIPHY B.V. THE NETHERLANDS

Drawn by: N.H. Beun
Approval:
Location: PCB 792*

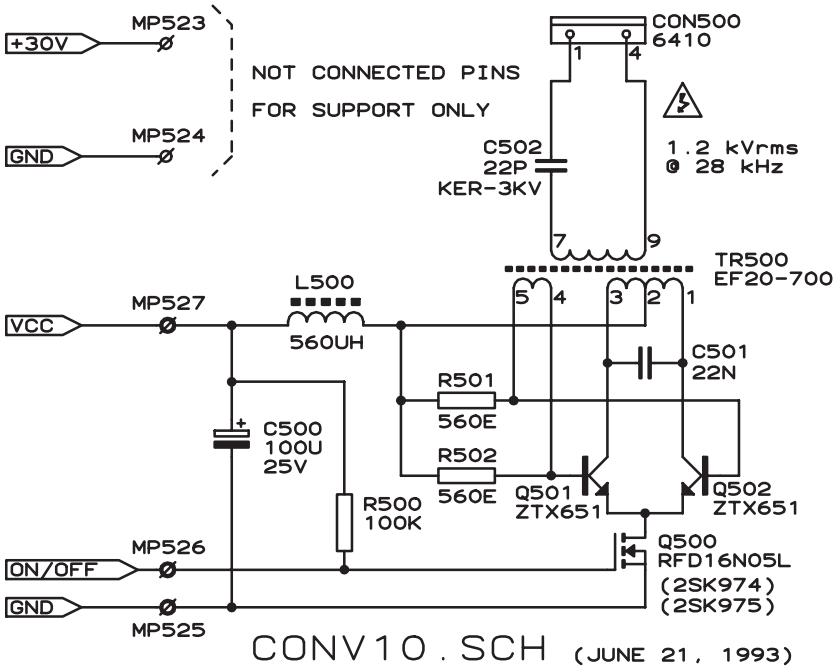
Title
790 MAINS POWER SUPPLY

Size	Document Number	REV
A	7900PSU.SCH	D

Date: December 15, 1997 Sheet 21 of 38

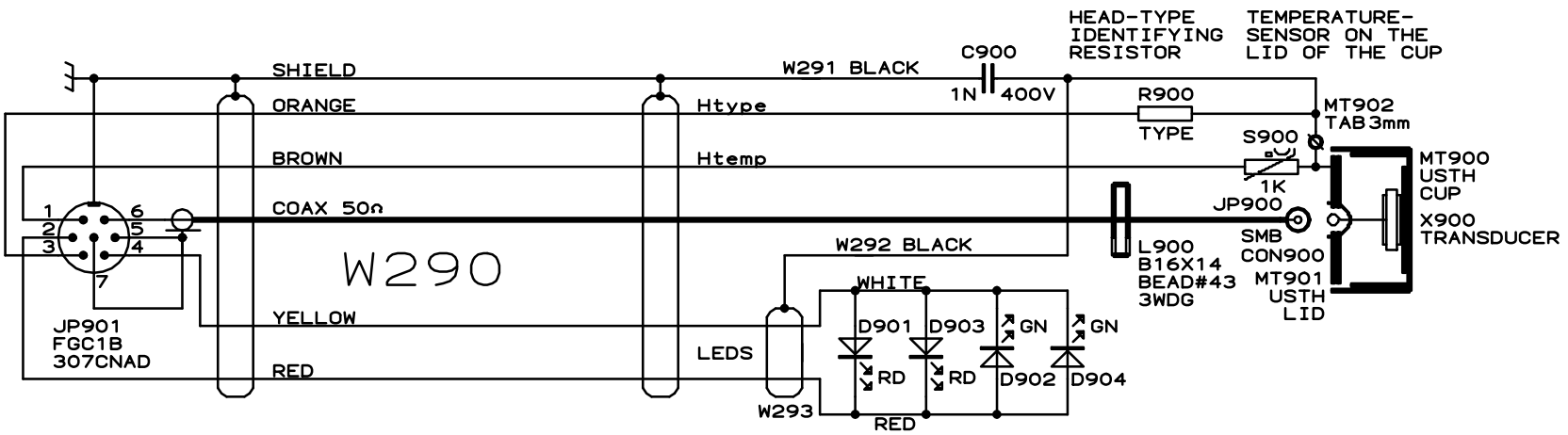


TO CCT IN
LCD-MODULE



CONV10.SCH (JUNE 21, 1993)

Property of: UNIPHY B.V. THE NETHERLANDS Drawn by: N.H. Beun Approval: Location: PCB CONV1*		
Title CONV10 BACKLIGHT CONVERTER		
Size A	Document Number 7900CONV.SCH	REV D
Date: December 15, 1997	Sheet 22 of 38	



TYPE	R900	X900	ERA
291	680E	D13	1cm²
292	2K2	D25	4cm²
293	6K8	D38	10cm²

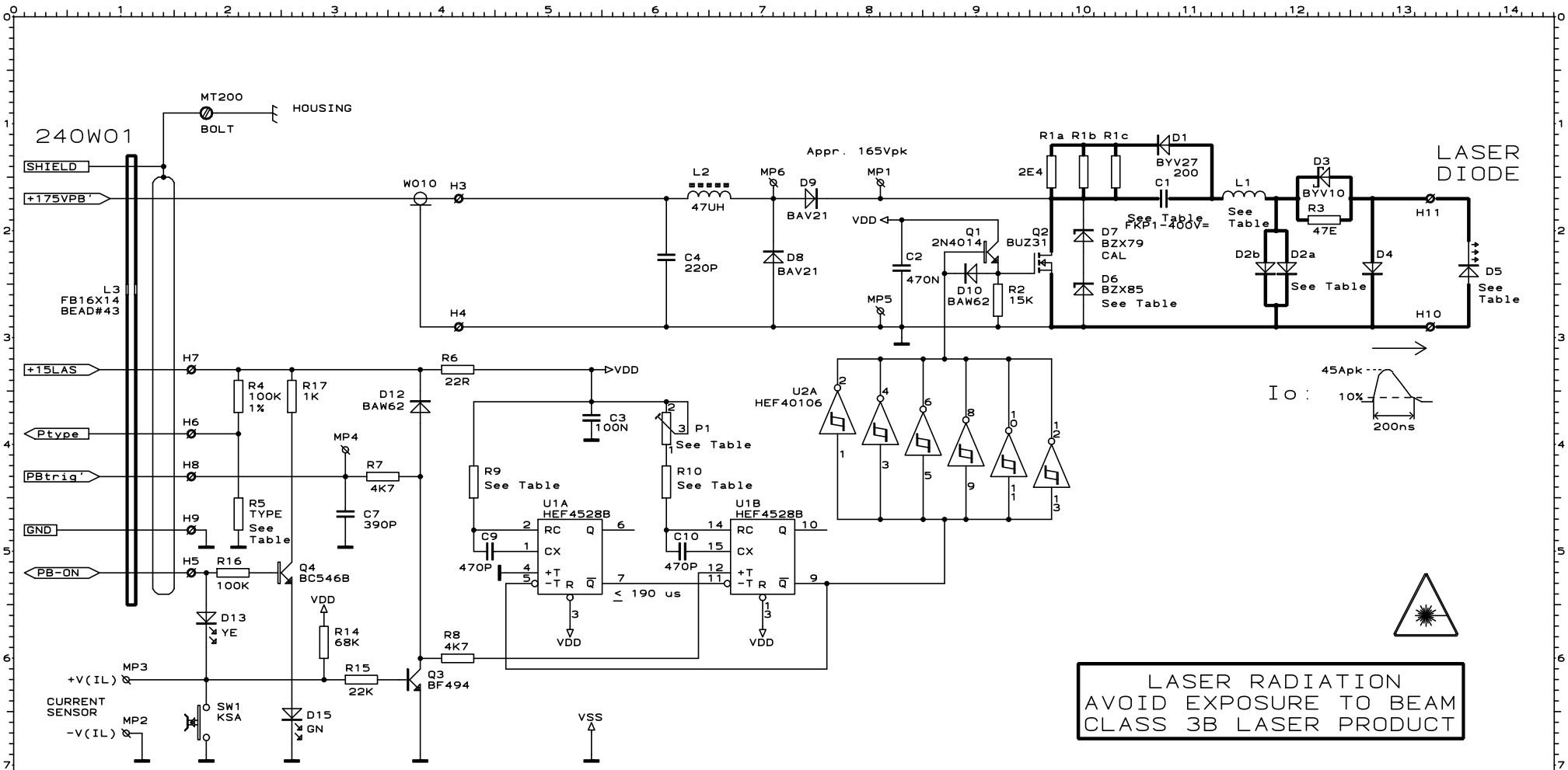
NOTICE: TYPE 293 IS OUT OF PRODUCTION

Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: US TREATMENT HEAD 29*

Title
290 US TREATMENT HEAD

Size	Document Number	REV
A	7900USPB.SCH	D

Date: December 15, 1997 Sheet 24 of 38



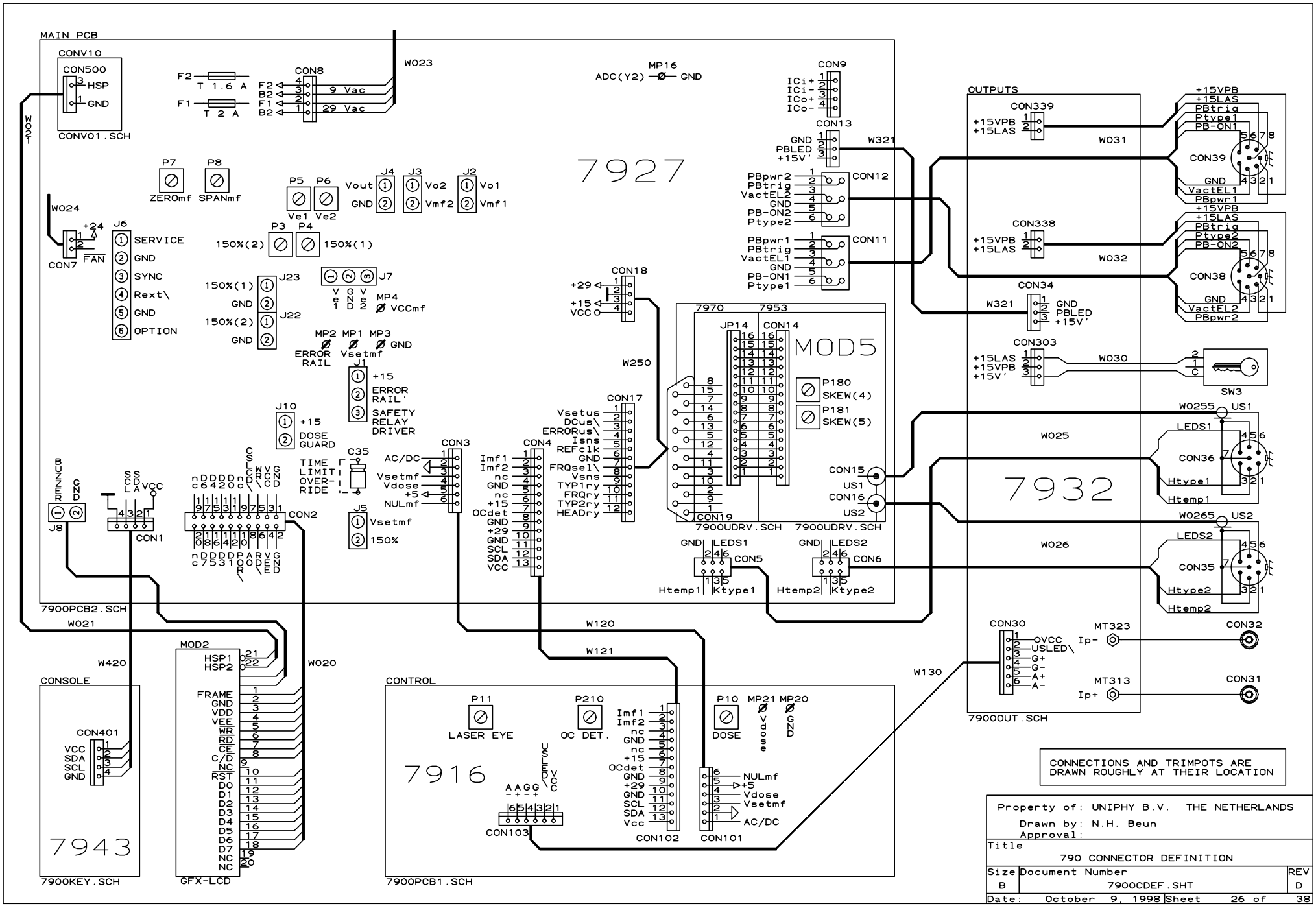
TYPE	R5	R9	R10	P1	C1	L1	D2a , D2b , D4	D5	D6
241	1K0	680K	220K	250K	22n	@ME241010	BAW62	LD65R	150V
242	1K8	680K	82K	250K	22n	@ME241010	BAW62	CVD68R	91V
243	6K8	68K	4K7	50K	22n	L245021	BAW62	CVD68R	43V
245	3K3	680K	150K	250K	33n	L245021	BAV21	4x LD79	150V
	15K								

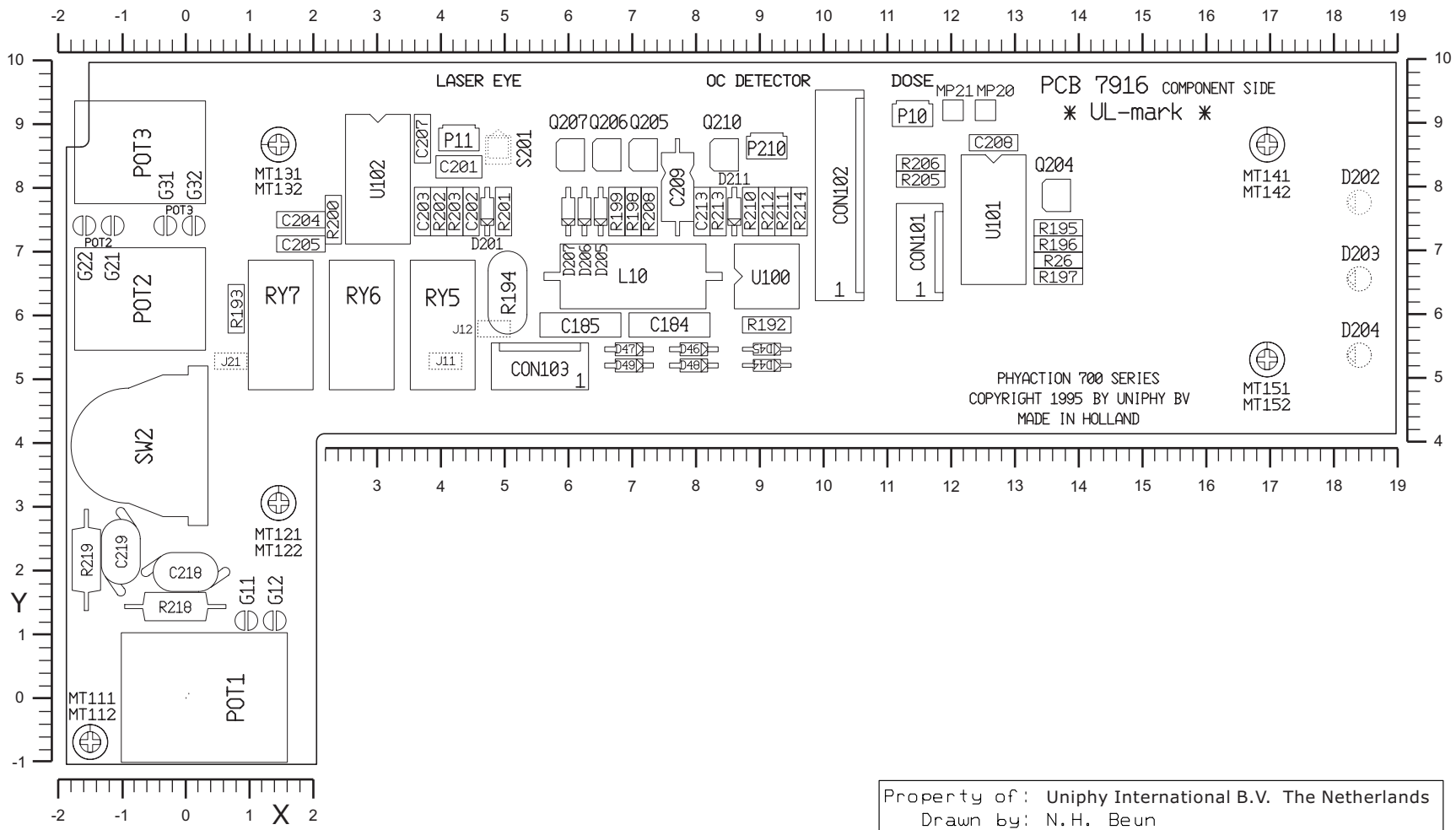
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Location: PCB 240*

Title
240 LASER-PROBE

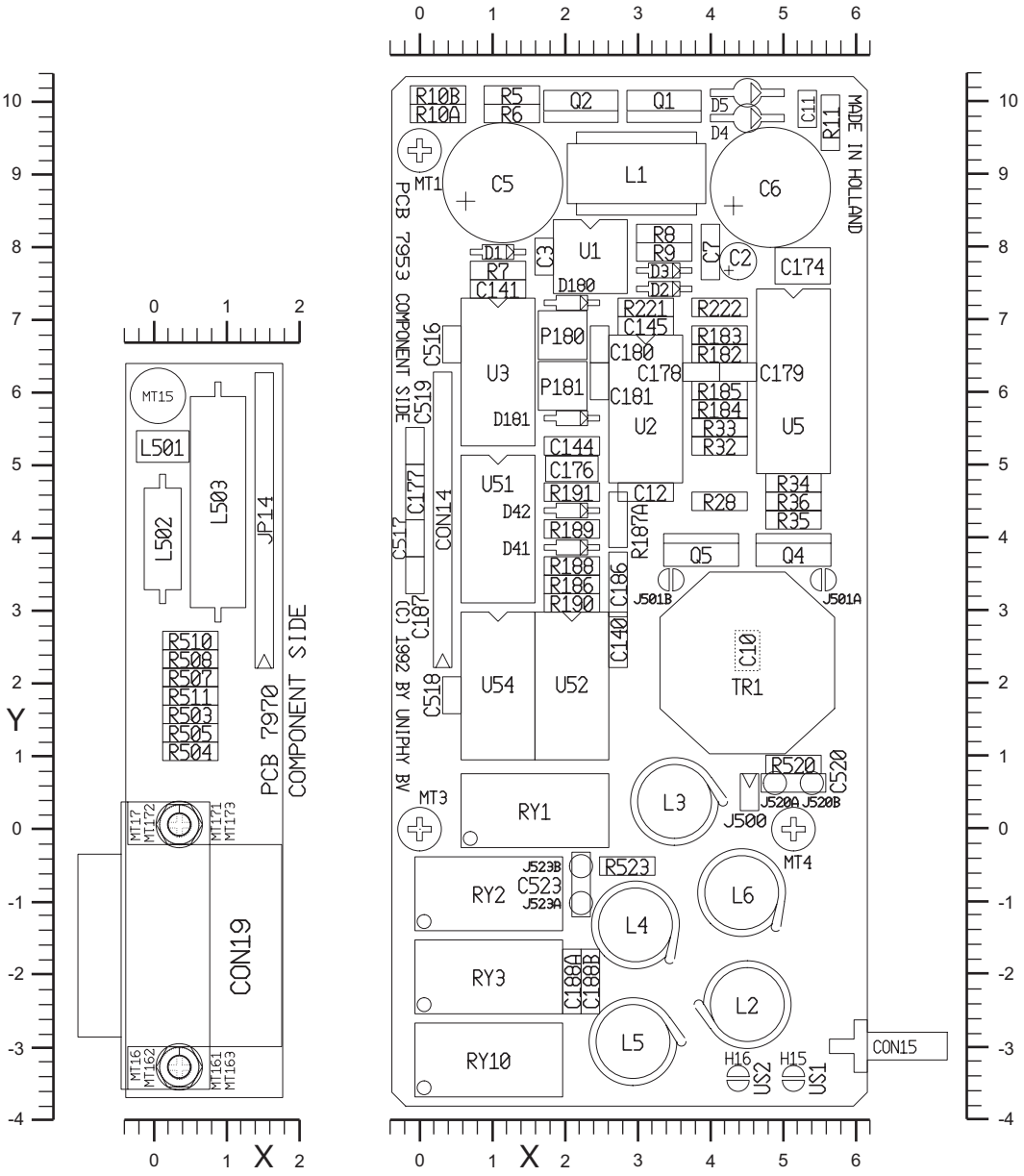
Size	Document Number	REV
B	7900LSPB.SCH	D

Date: December 15, 1997 Sheet 25 of 38

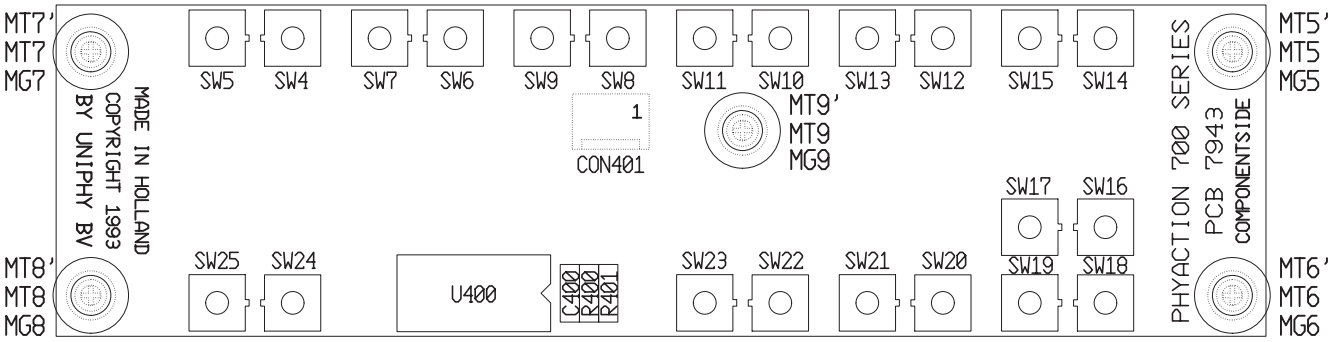

MAIN PCB
CONV10
CON500
HSP
GND
CONV01.SCH
W001
F2
T 1.6 A
F1
T 2 A
CON8
9 Vac
29 Vac
W023
7927
MP16
ADC(Y2)
GND
CON9
ICi+
ICi-
ICo+
ICo-
CON13
GND
PBLED
+15V'
W321
CON12
PBpwr2
PBtrig
VactEL2
PB-ON2
Ptype2
CON11
PBpwr1
PBtrig
VactEL1
PB-ON1
Ptype1
P7
ZEROmf
P8
SPANmf
P5
P6
Ve1
Ve2
J4
J3
J2
Vout
Vo2
Vo1
Vmf2
Vmf1
W024
+24
CON7
FAN
J6
SERVICE
GND
SYNC
Rext\
GND
OPTION
150%(2)
P3
P4
150%(1)
J23
J22
J7
MP4
VCCmf
MP2
MP1
MP3
ERROR
Vsetmf
RAIL
J1
+15
ERROR RAIL'
SAFETY RELAY DRIVER
J10
DOSE GUARD
CON18
+29
+15
VCC
W250
7970
7953
JP14
CON14
MOD5
P180
SKEW(4)
P181
SKEW(5)
CON19
7900UDRV.SCH
CON15
US1
CON16
US2
CON17
Vsetus
DCus\
ERRORus\
Isns
REFclk
GND
FRQsel\
Vsns
TYP1ry
FRQry
TYP2ry
HEADry
CON3
CON4
AC/DC
Vsetmf
Vdose
+5
NULmf
Imf1
Imf2
nc
GND
nc
+15
OCdet
GND
+29
GND
SCL
SDA
VCC
C35
TIME LIMIT OVER-RIDE
J5
Vsetmf
150%
BUZZER
GND
J8
SCL
SDA
VCC
CON1
CON2
nDDDDnCS\WRVGNC
c6420c\RCD
nDDDDDPARVGNC
c7531D\RDEDD
\R\
CON5
CON6
GND
LEDS1
LEDS2
Htemp1
Ktype1
Htemp2
Ktype2
7900PCB2.SCH
OUTPUTS
CON339
+15VPB
+15LAS
W031
CON39
PBtrig
Ptype1
PB-ON1
GND
VactEL1
PBpwr1
CON338
W032
CON38
Ptype2
PB-ON2
VactEL2
PBpwr2
CON34
W321
GND
PBLED
+15V'
CON303
+15LAS
+15VPB
+15V'
W030
SW3
7932
W025
W026
W0255
W0265
US1
US2
LEDS1
LEDS2
CON36
CON35
Htype1
Htemp1
Htype2
Htemp2
CON30
OVCC
USLED\
G+
G-
A+
A-
MT323
MT313
Ip-
Ip+
CON32
CON31
W130
79000UT.SCH
W021
W420
W020
W120
W121
CONSOLE
CON401
VCC
SDA
SCL
GND
7943
7900KEY.SCH
MOD2
HSP1
HSP2
FRAME
GND
VDD
VEE
WR
RD
CE
C/D
NC
RST
D0
D1
D2
D3
D4
D5
D6
D7
NC
NC
GFX-LCD
CONTROL
P11
LASER EYE
P210
OC DET.
P10
DOSE
MP21
MP20
Vdose
GND
7916
AAGG
CON103
CON102
CON101
NULmf
+5
Vdose
Vsetmf
AC/DC
7900PCB1.SCH
CONNECTIONS AND TRIMPOTS ARE DRAWN ROUGHLY AT THEIR LOCATION
Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:
Title
790 CONNECTOR DEFINITION
Size B
Document Number 7900CDEF.SHT
REV D
Date: October 9, 1998
Sheet 26 of 38



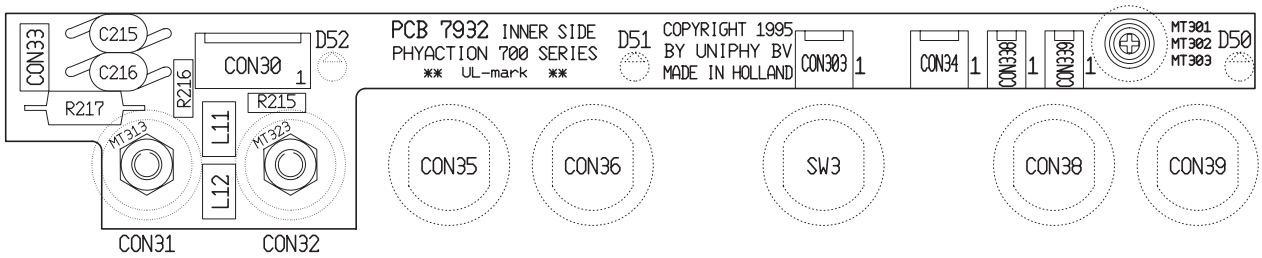
Property of: Uniphy International B.V. The Netherlands Drawn by: N.H. Beun Approval:		
Title: Component Layout PCB 7916		
Size: A4	Document Number: 7916.ps	REV: D
Date: August 23, 1995	Sheet: 29-1 of 38	



Property of: Uniphy International B.V. The Netherlands Drawn by: N.H. Beun Approval:		
Title Component Layout PCB 7953&7970		
Size A4	Document Number 7953.ps	REV D
Date: July 19, 1994	Sheet 33-1 of 38	

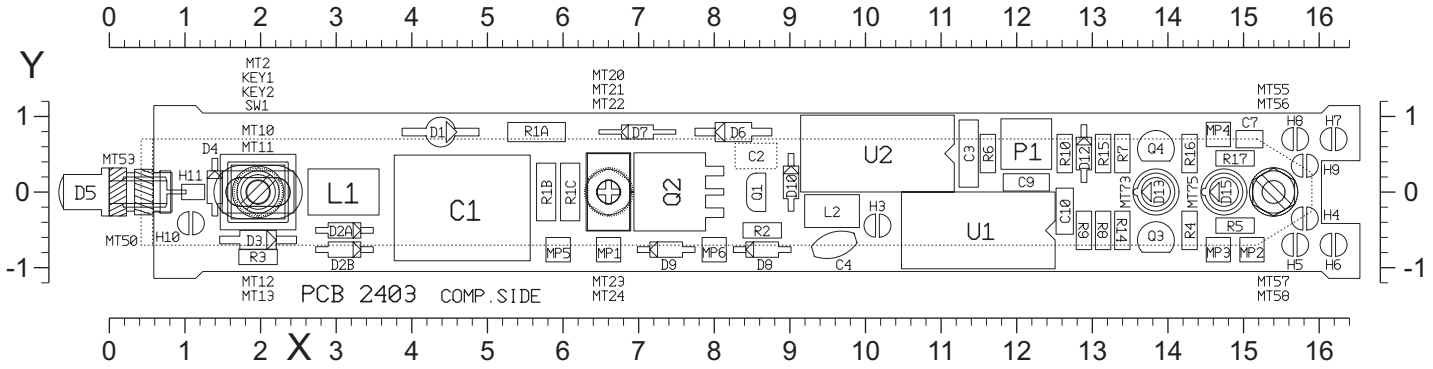


Property of: Uniphy International B.V. The Netherlands Drawn by: N.H. Beun Approval:		
Title Component Layout PCB 7943		
Size A4	Document Number 7943.ps	REV D
Date: December 23, 1992	Sheet 32-1 of 38	

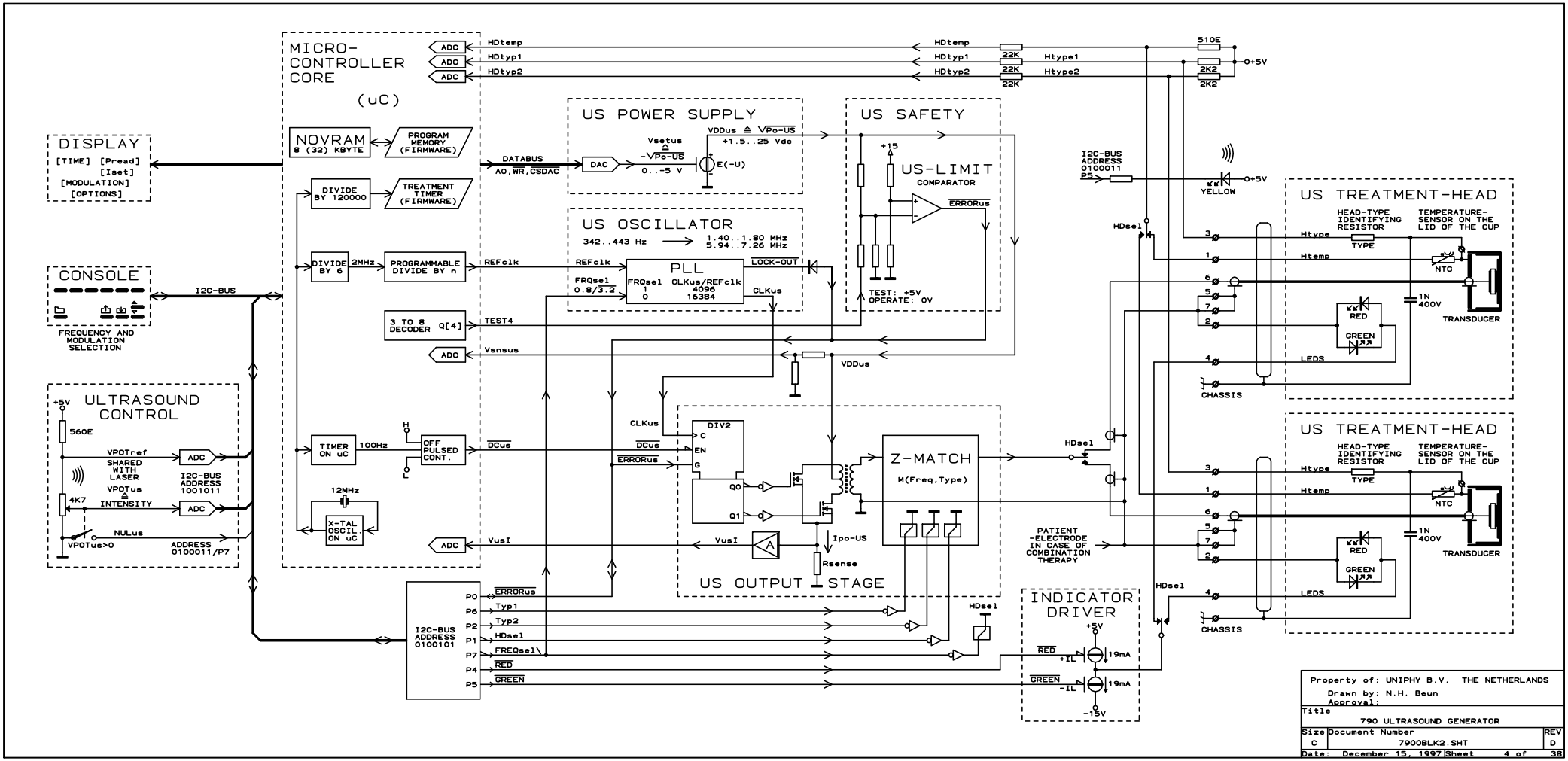


Property of: Uniphy International B.V. The Netherlands Drawn by: N.H. Beun Approval:		
Title Component Layout PCB 7932		
Size A4	Document Number 7932.ps	REV D
Date: August 24, 1995	Sheet 31-1 of 38	

Property of: Uniphy International B.V. The Netherlands Drawn by: N.H. Beun Approval:		
Title Component Layout PCB 7927		
Size A4	Document Number 7927.ps	REV D
Date: September 20, 1994	Sheet 30-1 of 38	

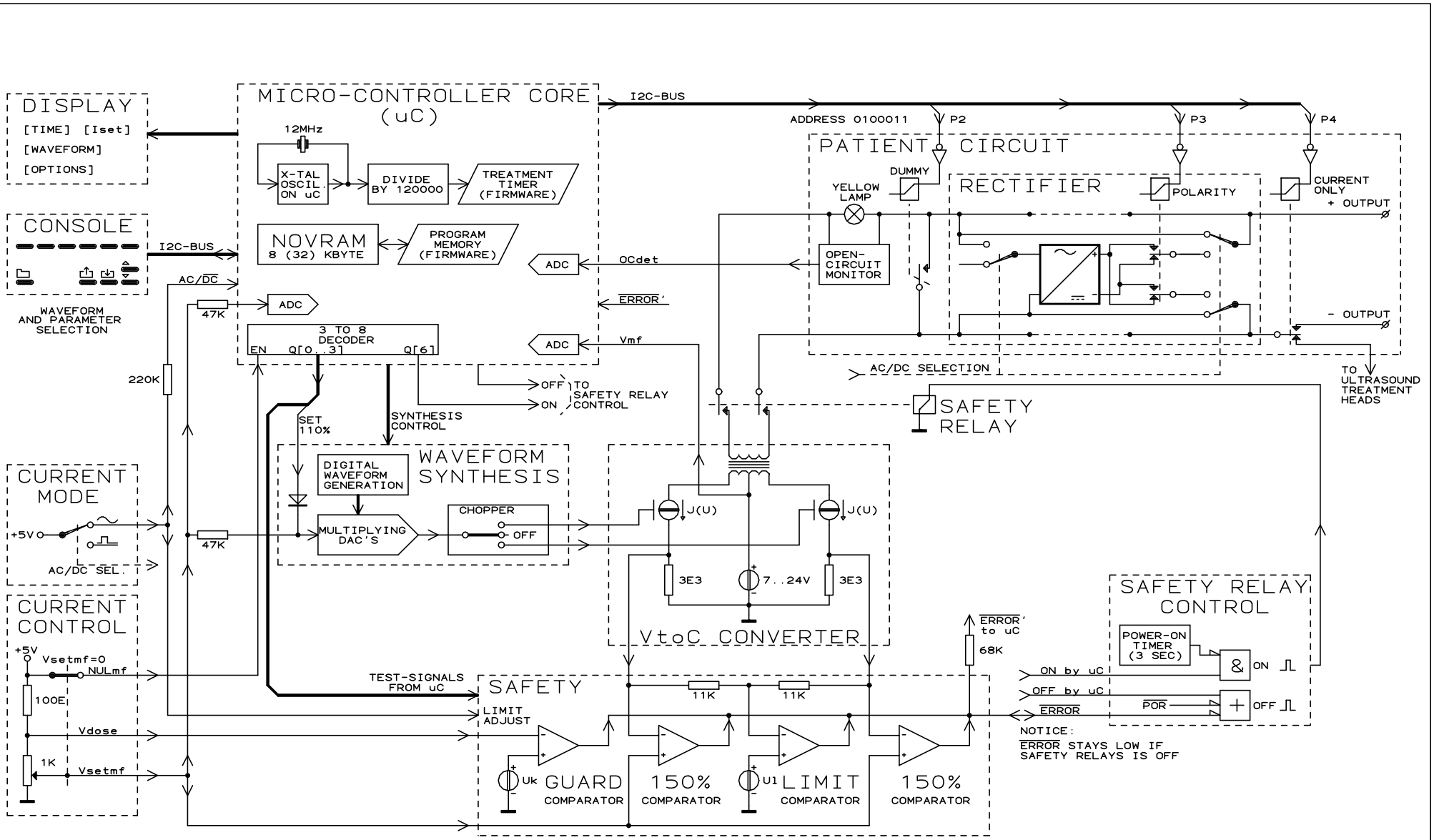


Property of : Uniphy International B.V. The Netherlands Drawn by : N.H. Beun Approval :			
Title Component Layout PCB 2403			
Size A4	Document Number 2403.ps		REV D
Date : November 11, 1992	Sheet 31 of 33		

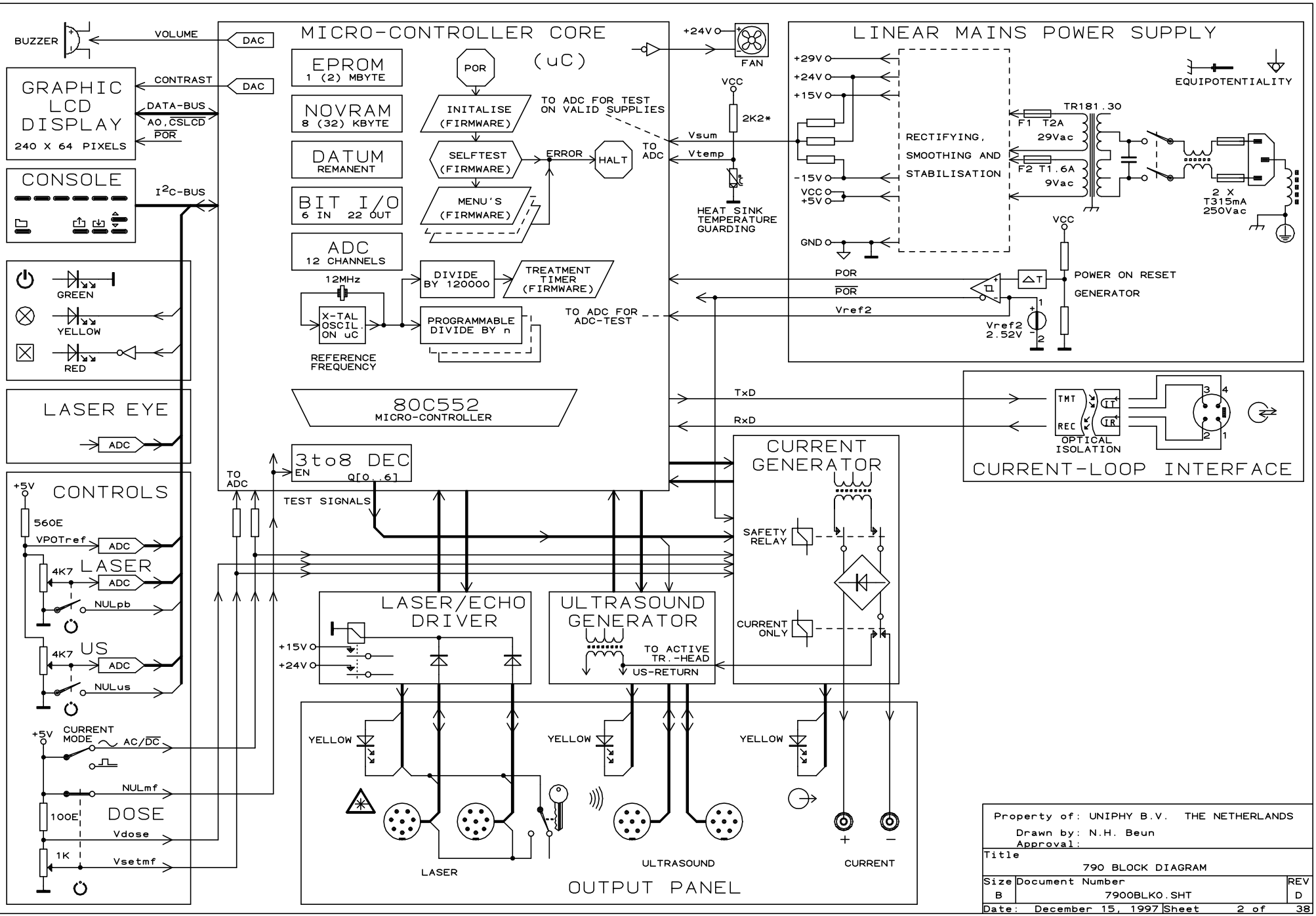


Property of: UNIPHY B.V. THE NETHERLANDS
Drawn by: N.H. Beun
Approval:

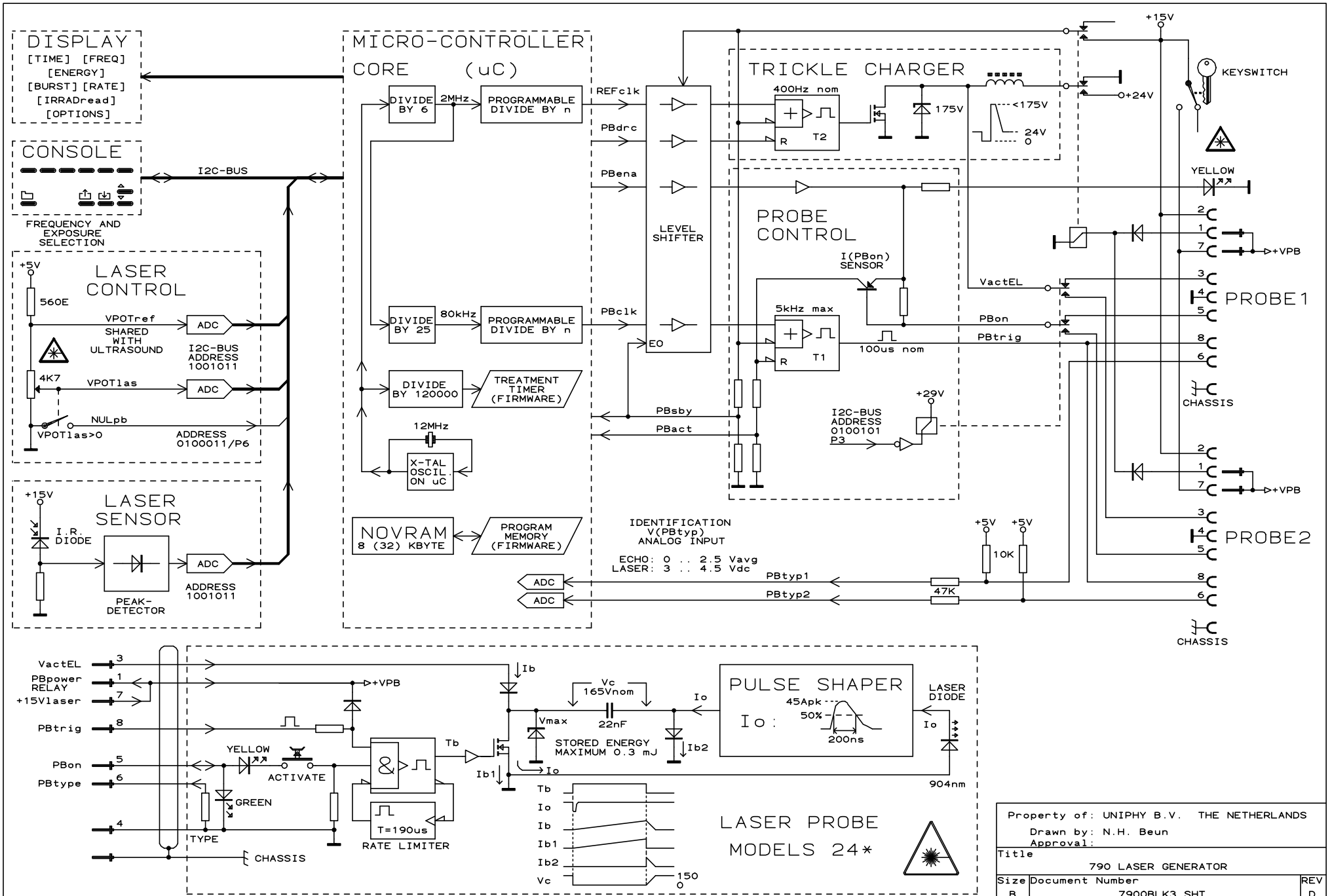
Title		
790 ULTRASOUND GENERATOR		
Size	Document Number	REV
C	7900BLK2.SHT	D
Date: December 15, 1997	Sheet 4 of 38	



Property of: UNIPHY B.V. THE NETHERLANDS		
Drawn by: N.H. Beun		
Approval:		
Title: 790 CURRENT GENERATOR		
Size: B	Document Number: 7900BLK1.SHT	REV: D
Date: December 15, 1997	Sheet 3 of 38	



Property of: UNIPHY B.V. THE NETHERLANDS		
Drawn by: N.H. Beun		
Approval:		
Title: 790 BLOCK DIAGRAM		
Size: B	Document Number: 7900BLK0.SHT	REV: D
Date: December 15, 1997	Sheet 2 of 38	



Property of: UNIPHY B.V. THE NETHERLANDS		
Drawn by: N.H. Beun		
Approval:		
Title: 790 LASER GENERATOR		
Size: B	Document Number: 7900BLK3.SHT	REV: D
Date: December 15, 1997	Sheet 5 of 38	